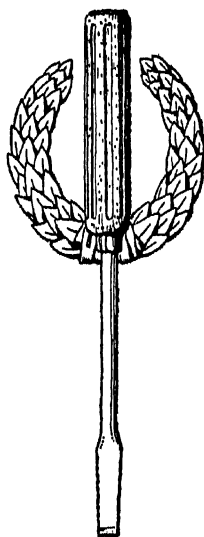


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A Life of Charles F. Kettering

by

ROSAMOND McPHERSON YOUNG

Decorations by Allan Thomas

DAVID McKAY COMPANY, INC.

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BOSS KET

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Eugene Kettering, too, cooperated in adding to the accuracy of the story of his father.

The willingness with which everyone who knew Kettering answered questions, wrote letters, and produced records speaks eloquently of the esteem and love they held for him.

Rosamond Young

FOREWORD

When a reporter asked my father how it feels to be one of the greatest living Americans, just after he had been given that award by the United States Chamber of Commerce, he replied, "They didn't need to make so much fuss. I'm just a plain old inventor."

This "plain old inventor" is the man who put the self-starter in your automobile, the knockless gasoline in your tank, the safe coolant in your refrigerator. He developed the diesel engine that pulls railroad cars across the continent. He hunted for ways to use the rays of the sun to increase the world's food and fuel supply. He searched for ways to cure cancer and other means to increase man's life span.

My father had little use for books about the past. "The only reason we should read about the past," he often said, "is to study the future, because that is where we are going to spend the rest of our lives."

When you read this story of Charles F. Kettering, remember that the inventions made by him and others who have gone before you are very few compared with those still waiting for a discoverer. Remember that there is unlimited opportunity in the future for the man or woman who can find ways to make the world a more comfortable place in which to live.

Perhaps you can be tomorrow's Charles F. Kettering.


Eugene W. Kettering

Hinsdale, Illinois



C H A R L E S F . K E T T E R I N G

I

 All the way from Loudonville, Ohio, out to Jacob Kettering's farm three miles east, the road winds uphill and down. The long legs of Charlie Kettering had taken their tall, skinny owner up and down those hills every day for four years, from home to Loudonville High School and back. Three pairs of tough, copper-toed shoes he had worn out on those hilly roads, and now on a nippy March afternoon in 1895 he was well into the fourth. Since one pair of shoes a year for each of the five Kettering children was the limit of Father Jacob Kettering's purse, Charlie skirted the puddles and watched for stones in the three-tracked road, two made by the buggy and wagon wheels, with a wider one between made by the horses.

It was not easy for Charlie to watch the road. A gawky eighteen-year-old, at six feet two the tallest boy in the senior class, he had to peer nearsightedly through thick-lensed spectacles. Without his glasses, Charlie could not see to tie his bootlaces. With them, his world stretched out a scant ten feet beyond his curious nose. But he knew every oak- and maple-covered hill over which the road climbed. He knew where the hickory nuts and walnuts covered the ground after the frost, where the mushrooms popped in the spring.

Now as Charlie's loping trot took him over the last rise before the long descent to his father's house, he lengthened his stride. It was late. He had stayed too long at the flour mill watching the new Corliss engine. His mother's wood-box would be empty and the water buckets, too.

Nearing the barnyard gate, Charlie made out the form of his pigtailed, snub-nosed younger sister Daisy sitting on the top rail of the fence.

"Where have you been, Charles Franklin Kettering?" she called out in a voice and manner exactly like her mother. "I've been home a whole hour waiting for you." Daisy was eleven and attended Big Run School only a mile from the Kettering farm.

"I had to be measured for my graduation suit after school," Charlie explained.

"I bet you went to the mill, too," Daisy said, sticking her lips out in a pout. "You like that old steam engine better than me."

Charlie opened the gate. "I'll say one thing," he laughed. "As noisy as it is when the steam exhausts, it can't hold a candle to you when you're mad." He lifted her down from the gate. "Now what did you want me for?"

Daisy's brown eyes clouded and a tear slipped out. "Trixie got killed."

"She did?" Charlie's voice rose an octave. Trixie, the mischievous calico kitten, was his favorite of the many Kettering cats. "What happened?"

"I guess one of the cows stepped on her," Daisy said, gulping now and sniffing. "You know how she always followed them everywhere. I found her out by the watering trough."

Charlie slipped an arm over her shoulders as they walked around the house to the kitchen door. "We'll have the funeral right after supper," he promised. "I have to get my chores done now."

"Mother's been looking for you for an hour," Daisy said darkly. "You better get the wood in."

Martha Kettering, in a starched calico dress with apron

to match, stirred a pot of beans on the black, wood-burning stove. She glanced over her shoulder at her bean-pole son as he shut the door softly behind him.

"You've been dawdling again."

"I'm sorry. I'll hurry."

"I'm out of wood and the water bucket's empty."

Charlie lifted the latch to the stairway door. He took the narrow, twisting stairs two at a time. In the large bedroom he shared with his brothers, Adam and David, he shucked off his school jacket and pants, hung them on a nail by his quilt-covered bed, pulled on his worn coveralls and a blue shirt his mother had made, set his school shoes under the bed, and pulled on his heavy, mudcaked work boots. Whistling under his breath, he took the steps downward three at a time, landing on the wooden kitchen floor with a bang that would have frightened his mother if she had not been expecting it. He dashed through the kitchen in five steps, grabbing up the kindling bucket as he went and rattling the dishes in the hutch cupboard. In a moment he was back with a bucket of splinters and an armload of cordwood. With a shattering clatter he dumped the wood into the box that yawned vacantly beside the stove.

"Do you have to be so noisy?" asked his mother, popping a slice of ham into a sputtering black skillet.

"It's heavy," he answered. "I'm sorry I was late, mother. I stopped in after school to see whether they had unloaded the new engine. They were unpacking it and they let me help."

"Didn't you stop to get your suit fitted?" Martha asked.

"Yes, I went there right after school. It's going to have padded shoulders."

"Padded shoulders!" exclaimed Daisy. "Like a Gibson man. Charlie's going to be a Gibson man!"

Charlie guffawed. Not even his mother, who was naturally prejudiced, could see any resemblance between her son's homespun face and the beautifully formed features of the men on Charles Dana Gibson's calendars. Not that Charlie was homely, but he was so thin and gawky that he looked like an owl-eyed Ichabod Crane.

"Quiet!" He gave a tug on his sister's braids. "Every boy in the class will have padded shoulders. It's the style. We aren't trying to look like Gibson men, but I'll bet you'd give your eyeteeth to look like a Gibson girl!"

"If I gave my eyeteeth I'd look more like a Halloween pumpkin," Daisy answered.

"It's ready to take up," Martha Kettering judged, stirring the pot on the stove. "Daisy, go call Emma. She's in the parlor. Charlie, ring the dinner bell."

"Where are they working today?"

"Up along the north fence."

Charlie stepped out on the back porch, grasped the bell rope and gave it a mighty tug. The black iron bell, mounted on a bracket near the eaves, set up a brassy clanging.

"I guess they ought to hear that," he remarked, returning to the kitchen.

"Here, son, put this down by your father's plate."

Charlie took the steaming bowl of ham gravy from his mother's hands and sniffed at it approvingly.

"You be careful of that bowl!" warned Martha. "Your grandmother Kettenring brought that from Germany. I wouldn't want it broken."

"You tell me that every time," Charlie told her. He set the bowl carefully on the blue-checked cloth. "Kettering," he repeated. "I'm glad Dad changed our name. Charlie Kettenring is hard to say."

"I think it is an improvement, too," his mother agreed.

Emma, tall, spare, with brown braids wound around her head, appeared in the doorway closely followed by Daisy.

"Smells good," she remarked. "What's for supper?" Older than Charlie by eight years, she had spent the day braiding rag rugs for her hope chest.

"Ham gravy, green beans, sweet potatoes, apple pie."

Daisy walked to the steamy window and rubbed a clear spot with her hand. "I wish they'd hurry," she said. "Oh, I see them now. They're out by the barn!"

"Dish up then, Emma," Martha requested. "Charlie, have you washed?" Without a word Charlie headed for the pump on the back porch.

By the time the men came into the kitchen, the table creaked with steaming dishes. Martha set down a plate of homemade bread, a pat of butter, and a cut-glass dish of grape jam. Then she sat down at the end of the table, nearest the stove. The others did not wait. Jacob Kettering, bronze-faced and bearded, sat at the other end. The older boys, David and Adam, sat on one side of the table, while Charlie, Emma, and Daisy sat on the other.

They all bowed their heads briefly while Jacob spoke a few words of thanks. Then followed a silent passing of the dishes while Martha poured coffee boiling hot from a granite pot. The men of the family ate steadily, silently, and swiftly. Daisy chattered to Emma about Charlie's new suit.

At last Jacob put his bone-handled knife and fork cross-wise on his plate. "You get measured for that suit today, son?"

Charlie nodded. "Yes."

The graduation suit was to be Charlie's first. His mother had made all his clothes up to now.

"Seems to me it's a mighty big expense, a new suit for

every boy in the graduating class. Likely none of them will ever wear those suits again."

"Charlie could wear his for a wedding suit," David suggested. "It's got a stand-up collar and white tie, I hear."

"Wedding suit!" snapped Martha. "You're a fine one to be talking about Charlie needing a wedding suit, David Kettering! There you sit, thirty years old, and Adam beside you twenty-five years old, and no sign of a bride, either one of you! I declare, I hoped to hold a grandchild of my own in my arms long before this."

Both girls blushed at their mother's outspoken words. Adam and David looked down at their plates.

"Now, now, Martha," soothed Jacob, "no need to go pushing our chickens out of their nest before they're ready. I've no doubt there'll be plenty of grandchildren before you and I are carried to the graveyard."

"Anyhow Charlie won't be needing his suit for any wedding," Daisy put in. "He is afraid of girls."

"I'm not either!" Charlie spoke hotly. "Girls are just unnecessary to my life, that's all! I've got big plans and they are more important than girls! And they include wearing the suit, too, and not just on Sundays, either."

"And just what are these big plans, son?" asked Jacob.

"I want to go to college."

The Ketterings stared at Charlie as if they had never seen him before. The awkward boy with wiry curly hair springing from a neat middle part stared back owlishly through his thick-lensed spectacles.

"College!" Jacob Kettering spoke the word with an explosion of breath. "Whatever put that idea in your head?"

"I have had it in mind for a long, long time," Charlie replied.

When Jacob spoke again, his voice had a kinder tone.

"Why, boy, college isn't for a poor farm boy like you. Your brothers, father, and grandfathers as far back as I know about them have been farmers, working with their hands in the soil. What's wrong with that?"

"There's nothing wrong with it," Charlie said.

"I thought you liked farming, son."

Charlie's eyes kindled. "I do. I always did. I like plowing and planting and going after the cows. But I want to go to college. What's wrong with that?"

"The main thing wrong with it, Charlie," said Jacob patiently, "is that college is expensive. It's for rich men's sons. You're the son of a farmer who is doing well to buy his children one pair of shoes a year."

"I didn't ask you for any money," Charlie said in a level tone.

Martha Kettering recognized the danger signs in her son's face and voice. Although his was a loving nature, he had an explosive temper that he had not learned to control. "And what were you thinking of studying in college, son?" she asked.

Charlie gave her a short answer. "I don't know yet. Maybe I'll study to be a professor."

David laughed. "A professor? What makes you think you could be a professor? Why don't you be a mechanic and learn to run that Corliss engine you're always talking about? Or maybe you could repair sewing machines. Remember?"

The whole family laughed, even Charlie. When Charlie was seven or eight, shortly after scarlet fever had left him nearly blind, Jacob Kettering had bought his wife an Elias Howe sewing machine with a year's corn money. Whenever Martha Kettering used the machine, Charlie hung around like a bee around clover, sticking his nearsighted eyes so close to the needle that more than once his mother almost

stitched his nose. He particularly liked to watch her wind the bobbin. He loved to see the thread traveling back and forth, wrapping itself neatly around the bobbin shank.

One Saturday, while his mother was in the kitchen doing the week's baking, Charlie slipped into the spare bedroom that had been converted into a sewing room. In midmorning Martha went in for a thimble, planning to mend some socks while the bread baked. In the doorway she stopped, too shocked to speak. There on the floor sat Charlie, surrounded by what looked like scores of pieces of her sewing machine.

Finally she found her voice. "Charles Franklin Kettering! What are you doing?"

Charlie looked up, an innocent expression on his face. "I wanted to see what makes it run," he told her.

She stood still in the doorway, hands on hips. "You wanted to see what makes it run? Charlie, have you the slightest idea what you have done? Do you realize how much your father paid for that machine? Do you?"

Charlie looked troubled. Tears began to roll down his cheeks. "I didn't ruin your machine, mother," he told her. "Honest, I didn't."

She took him by the arm, so thin inside the shirt she had made him on that very machine. "Just how do you figure that?"

"I can put it back together; really I can, Mother!"

She let go his arm. "I'm going to sit right down here and wait," she said. "And if you can't make it work—" She let the threat dangle. She had never paddled her son. The boy had never given either parent the least trouble. But he was mighty near a paddling now, and he knew it.

The boy worked slowly, stopping to wipe each piece with an oily rag before he fitted it into the machine. The bread

was done, and Martha stirred up a batch of ginger cookies and still he hadn't finished. Just before time to get the noon meal he called her.

"Come in and try it now, Mother."

The pieces had disappeared from the floor. Charlie had threaded the machine and wound a fresh bobbin. "Try it," he invited.

Martha put a scrap of calico under the needle and put down the presser foot. Giving the wheel a turn with her hand, she picked up the rhythm with her foot, watching the needle dip in and out of the goods, leaving a trail of neat stitches. She stopped the machine and looked at the goods on the underneath side. Then she put an arm around her son, standing with his nose near the needle.

"Son, I'm sorry I spoke so sternly to you," she said. "It sews better than it did when it was new."

When Jacob heard the story from his wife, he scratched his head thoughtfully. "Now how do you suppose that youngster ever learned how to put that machine together?" he asked.

"He told me he learned by taking it apart."

"I know he is interested in the tools out in the barn, of course, but none of them is in the least complicated."

"Maybe he inherited a kind of mechanical bent from you, Jacob."

Charlie's father shook his head. "He never got it from me, nor from anybody in our family, as far as I know. I can put up a barn so it won't fall down, but if I laid a finger on your sewing machine—well, that would be the end of it."

When David heard about the sewing machine, he laughed. "You should watch Charlie dig potatoes sometime if you think he's a mechanical genius. Last time we went out to

dig, he spent the solid morning hauling tools out from the barn, trying to find a better way of digging potatoes than using a spade and a potato hook!"

"Did he find one?" asked Jacob.

"He dug one row while I did twelve."

On another occasion, while he was a young boy, Charlie made his family wonder just what kind of a person he was. The fall he entered Loudonville High School, he earned fourteen dollars helping a neighbor cut corn. He proudly brought his pay, the only money he had ever had, to show his father.

"Will you let me spend it the way I want to?" Charlie asked.

"That's quite a sum of money, son," his father pointed out. "You certainly wouldn't spend it foolishly, would you?"

"No. I have something very useful in mind."

"What is it?"

Charlie hedged. "I'd rather not—I mean if I earned the money—I mean—do I have to tell you?"

"No, I suppose not. But you will be sensible, won't you?"

"Of course." And for an hour Charlie became very busy with pen and ink and a mail order catalog.

Several weeks later David found a package from Chicago at the post office for Charles F. Kettering. He left it on the kitchen table for Charlie to find when he returned from school.

When he arrived home that night just in time for supper, all the family gathered around to watch him open the package. The boy was so excited his hands shook, tearing off the paper. Finally, however, he took his prize from the box and set it down on the table.

"Isn't it a beauty?" he asked.

Jacob's eyebrows rose as he saw what his son had bought.

"What on earth, son, do you want with a telephone? You certainly can't use it."

"Not to talk to anybody, I know," Charlie answered, bending close to get a good look at it.

"You certainly can't," Emma snapped. "There's only one telephone in the whole county."

"Two," corrected Charlie. "They've got one at the drug-store now and one at the depot. But I didn't get it to talk over."

"Then what—" But Charlie had gone to get a screwdriver.

After supper that night, Charlie showed his family how a telephone was made. "See this?" He showed them a piece of steel with an armature wrapped around it. "When this is connected to a dry cell, it makes a magnet. We learned about them in science class. A magnet can reach out and pull a piece of metal to it and hold it there."

Charlie's folks looked at him. Fourteen dollars just to see what was on the inside of a telephone!

Now eighteen-year-old Charlie, about to graduate from high school, faced his family. "I don't want to repair sewing machines. I don't know for sure what I want to do yet. But I do want to go to college to prepare for whatever I do decide on. I didn't expect you folks to send me. I'll earn my way."

"How?" Adam asked.

"I can get a school to teach this fall," Charlie said. "I'll teach until I can save enough for my tuition. I can earn my room and board and books when I get there."

"I see you've been doing some planning," Jacob commented. "And what college were you planning on?"

"Wooster," Charlie said. The College of Wooster was only a few miles from Loudonville.

"My gosh, I hope you don't teach at Big Run School," Daisy suddenly said. "It would be perfectly awful to have your own brother for a teacher!"

"It wouldn't be half as bad as having your own sister for a pupil."

"Let's have no bickering, children," admonished Martha.

The shelf grandfather clock in the sitting room bonged six.

"It's late," Jacob stated, getting to his feet.

"But is it all right with you if I try to get a school this fall?" Charlie wanted to know. "I can help you on the farm all summer and on week ends in the fall if I get a school close enough."

"We'll see," said Jacob. "Plenty of time to talk about it. Time now to get out to the barn, boys. The cows will wonder what's keeping you."

"Cows don't think much," Adam said. He and David did the milking. Charlie's chore was to take the cows out to the far pasture after the milking and to fetch them in the morning. Jacob ran the cream separator, Emma's job was the much hated one of washing up the separator and the milk cans. Daisy and her mother did the dishes.

Adam and David left to go to the barn. Emma started to clear the table, having promised Daisy to start her job in view of Daisy's bereavement and the funeral services.

"Will you put Trixie's name in the Bible?" Daisy asked her father. Jacob smiled. It was Charlie, the sentimental cat lover, who had first started the practice of inscribing the names of all dead pets in the family Bible. Daisy had taken it up when she joined Charlie in holding funeral services some two years before.

"I'll get the Bible," Charlie offered.

Jacob sat down at a table near a window in the sitting room. He hooked a pair of steel-framed spectacles over

his ears. When his son laid the family Bible on the table in front of him, Jacob turned to the page where the family births and deaths were recorded. With work-gnarled finger he ran down the list of names, written in spidery black ink:

Melchior Kettenring, born July 25, 1815, died October 10, 1887.

Christina Preis, his wife, born January 10, 1815, died April 14, 1894. Under their names were listed all of Jacob's brothers and sisters. Last on the list was John Franklin Kettenring, from whom Charlie took his middle name.

Charlie looked for his own name on the page. It was there where it belonged, between that of *Adam, born December 21, 1869*, and *Daisy, born November 20, 1884*. *Charles Franklin Kettering*, the spidery handwriting said, *born August 29, 1876*. It was by far the handsomest name on the page, he thought, and by far the most important birthday.

On the back of the page were inscribed the names of cats long dead. Now Jacob added the name of Trixie, and the date of her death, March 10, 1895.

"I suppose you two are holding services?"

"Yes," Daisy answered.

"Then run along before it's time for your chores."

On the edge of the wood that skirted a hilly pasture behind the barn stretched a row of tiny graves where the pets of Charlie and Daisy lay buried. Now in the early twilight brother and sister hurried toward the spot, Daisy carrying a shoe box in which lay the body of Trixie, and Charlie carrying stakes, string, and a spade. Daisy indicated a spot next to the grave of Flossie, who had done battle with a passing dog and lost.

With the string Charlie measured the shoe box and staked out a rectangle in the loamy soil under a pine tree.

Neatly he cut out the rectangle with his spade, piling the dirt by the grave. When he finished, he had a perfectly regular hole that allowed just enough space for the box to fit comfortably. Using the staking strings, he laid supports across the grave for the box. With the box suspended over the grave, Charlie stood quietly while Daisy recited the Twenty-Third Psalm. In a high tenor he joined her in the Lord's Prayer and one stanza of "Lead, Kindly Light."

The service over, Charlie carefully lowered Trixie to the bottom of the grave, after which he shoveled the dirt in, neatly mounding the excess on top.

"I guess there aren't any flowers blooming this early," Daisy said dolefully. "Poor Trixie."

"I think I know where we might find some," Charlie suggested. "Up in the woods is a spot where the trailing arbutus grows. Sometimes it even blooms in the snow."

"Let's go see."

Charlie led the way. Sometimes he felt it was a little beneath the dignity of a high-school senior to be holding funerals of cats with an eleven-year-old girl, but he loved every cat on the farm and his sister, too.

"I really didn't mean what I said about having you for a teacher, Charlie," Daisy confessed as they climbed the woody path.

"I didn't mean what I said, either."

"If you go away to college, who'll I have funerals with?"

"Emma, maybe. Look close, Daisy. It's just about here the flowers are. I always remember that big oak tree over there. Look around in the hollows under the leaves."

Daisy went down on her black-stockinged knees. After a few moments' grubbing, she exclaimed, "Is this one? I think this is one. Look. Charlie!"

Charlie knelt down, peering owlishly where she pointed.

A cluster of delicate pinkish flowers sent a spicy fragrance to his nose. "That's it." He pulled one of the sprays. "See, the leaves have spots of red in them. Take this one. It will be enough."

Daisy got to her feet, sniffing the blossom. "We'd better hurry," she said. "They'll be ready for us." She meant the dishes and the cows. "What will you study in college, Charlie?"

It was easier going downhill than it had been coming up. "I wish I knew. There are so many things I want to know, but I'm not sure they teach the answers in college. Professor Budd didn't know when I asked him, and he went to college a long time."

"Isn't he the principal of Loudonville High?"

"Yes, and my physics teacher, too."

"Well, I can't imagine anything a smart man like Professor Budd wouldn't know."

"I'll tell you one thing. One day when it was raining, I was watching the drops run down on the outside of the window. I asked him why I could see through the glass."

"Why you could see through the glass?" Daisy stopped in her tracks. "Why everybody knows the answer to that. Even I do."

"You do? Tell me."

They walked on slowly. "Glass is transparent. We had it in spelling just this week, that's how I know. I had to look it up."

"Professor Budd said the same thing. 'You can see through glass because it is transparent,' he told me. So I looked up *transparent* in the dictionary. It says *transparent means capable of being seen through*. In other words you can see through the glass because it can be seen through."

"I see," Daisy said, frowning. "I guess I see."

They had come out of the woods now. When Daisy had laid the flowers on the grave, they started for the house.

"Take a grain of corn," Charlie continued. "It's a little thing, not as big as the end of your finger. You put it in the ground and up comes a stalk as tall as you, Daisy, with two ears of corn about a hundred or more grains on each ear. Why that stalk must weigh three thousand times what the original grain weighed! And that little grain did it with nothing but sun and rain and soil. Now how does it do it?"

"I don't know," Daisy said.


"Professor Budd didn't know," Charlie went on. "He said nobody knows. Well, that's one of the things I want to find out."

Daisy had had enough of this kind of talk. "I hope you find out someday, Charlie, if that's what you want to know. I've got to hurry now. The dishes will be waiting for me." She skipped on ahead of him, her pigtailed jouncing on her back in the twilight.

Charlie put the spade, stakes, and string away. Then he went around back of the barn to see whether the milking was over.

It was. The cows had waited for him to start the long walk to the far pasture.

2

 Charlie's graduation suit, with its braid-trimmed coat that had tails reaching below his knees, made him look quite handsome in his family's estimation as he stood up to give his graduation speech, "Yet Gleaners," at the 1895 commencement exercises at Loudonville High School. When a neighbor sitting next to him asked Jacob what Charlie was planning to do, Jacob proudly replied:

"He's going to teach at Bunker Hill School to earn money to go to Wooster."

"And what will he study in Wooster?" the parent pursued.

"Maybe he'll be a professor," Jacob told him. "His mother would like him to be a preacher, but I don't think he leans much that way."

His mother had little hope of Charlie's becoming a preacher, but she did ask him to promise to attend church when he left home for the Bunker Hill community some five miles from the family home. It was close enough for Charlie to come home week ends, but the taxpayers who provided Charlie's monthly salary of twenty-five dollars expected him to stay in the neighborhood and take part in community affairs.

The day before school was to begin, Charlie arrived at the building, unlocked the door, and stepped inside. It smelled hot, musty, and unused. The school, he saw, consisted of one large room much like Big Run School where he had learned his reading and figures. About forty desks

ranging in size from big to little faced the front of the room where a teacher's desk sat on a raised platform. At the side of the teacher's desk stood a big Ben Franklin stove. On both sides of the room four tall narrow windows looked out into the schoolyard.

Charlie dusted the room and looked over the stacks of arithmetics and McGuffey's Readers on a table by his desk. Leaving an object he had brought from home on the desk, he locked the door and walked to the Easlys', where he was to board. He was ready for whatever the following day might bring.

Arriving early the next morning before any of the pupils, he spent an anxious half-hour at his desk. Finally he saw by the watch his brother David had loaned him that the time had come.

He stood up, slipped it into his watch pocket, buttoned his coat, a blue serge one his mother had made for him, and started for the door.

Charlie was nineteen and scared. He had been told by more than one person that the big boys at Bunker Hill School made it a regular practice to run the teacher out of the job. In fact, the reason he had been hired was that the former teacher had been beaten by one of the boys and no one in the community cared to take the job.

Charlie took a deep breath and stepped out into the vestibule, which served as a cloak hall for the students. With his long fingers he grasped the bell rope. *Ding ding, ding, ding, ding, ding*, the bell clinked.

In the schoolyard games stopped with the last *ding*, and the boys and girls lined up in front of the door, shortest first, tallest last. Charlie stood aside, motioning for the line to move. Some of the pupils walked past him with eyes straight ahead, others cut a round-eyed glance as they

went by. A few toward the end of the line stared at him boldly.

With considerable shoving and rustling, the pupils found their seats. As Charlie walked to the front of the room, he counted thirty pupils. Several of them, he had noted, were as tall or taller than his own six feet two.

He felt thirty pairs of eyes on his back as he stepped up on the platform. Swinging around to face them, he smiled. "Good morning," he said and waited.

"Good morning, teacher," chorused the group.

He took a deep breath and put his boyhood behind him. "My name is Charles Kettering," he told them. "I am to be your teacher for this year. I am sure that most of you are familiar with the rules of the school." For the benefit of new students and to refresh the memories of others, he went over the rules for attendance, behavior, and study. "I expect," he concluded, "that these rules will be obeyed." Picking up the object he had laid on the desk yesterday, he showed it to the pupils. "This piece of wood is walnut, an extremely tough and durable wood. Even when it is struck against wood or stone or metal it does not splinter. You will notice that I have rounded it into a thick and durable paddle with a narrow place at one end so I can get a good grip. Now I want to make you a solemn promise: I will use this on the back of the first boy who breaks one of the school rules."

He looked at each pupil even though the ones in back were mere blobs to his weak eyes. They didn't know that, and he didn't plan for them to find it out, either. Laying the paddle down, he continued, "I want all those who passed to the eighth reader last year to bring up their report cards."

The first day at Bunker Hill School passed without any untoward incident. He gave out all the schoolbooks, as-

signed seats, and heard everybody except the beginners read. He found that he would have to teach reading, spelling, writing, arithmetic, geography, and history to eight different grades.

Charles turned out to be the kind of teacher who had no need for a paddle. His students liked him, partly because of the way he taught.

Sometimes instead of having spelling from a list in the speller, he assigned a story in a magazine, *Munsey's* or *The Saturday Evening Post*, asking the class to be prepared to spell all the words in the story.

He tried to make even the youngest pupils think. One day when a third-grader had just finished saying the nines table, Charles asked him what six times nine was again.

"Fifty-four."

"How do you know?"

"I learned it in the tables."

"Where did you get the tables?"

"In the arithmetic book."

"Did you ever check to see whether the book was right?"

The third-grader looked at him.

"Maybe six times nine isn't fifty-four," Charles said. "Maybe it's fifty-three or fifty-five. You can't be sure of everything, you know, unless you check. And what is six, anyhow? Where did six come from? How do you know that six means six?"

By that time the whole school was listening. "See if you can find out where six came from," he challenged them. "See whether you can prove that six times nine is fifty-four."

The next day a seventh-grader brought in fifty-four pebbles and proved that nine times six is fifty-four. Nobody in Bunker Hill School ever forgot that lesson.

Early in the spring of 1896, some of the larger boys

missed school for several days to help their fathers plant corn. When they came back to school, Charles talked to them at recess time. "Why did you boys plant corn this particular week?"

Andy Easley spoke up. "Because it is the light of the moon."

"What has that to do with it?"

Andy grinned. "You're from a farm, Mr. Kettering. You know corn has to be planted in the light of the moon."

"I know some farmers say it does. But I would like to know why."

"It's in the almanac. Things that fruit above the ground have to be planted in the light of the moon. Things that fruit below the ground have to be put in in the dark of the moon."

"How did the fellow that wrote the almanac know that? Did he try it?"

Andy shrugged.

"Tell you what," Charles said. "Let's try an experiment. Why don't you plant a few rows in the dark of the moon and find out?"

The boys enthusiastically agreed to the experiment. But the next day a committee of farmers waited on Charles after school. Mr. Easley was the spokesman.

"Mr. Kettering," he said, "farmers around here been raising corn long before you were born. We know all there is to know about raising corn, and what we know we can pass on to our sons. Now we hired you to teach our boys things that we don't know, things that are in the books. Now you just leave the corn planting be and stick to your books."

Charles had begun to develop a kind of scorn for what was in books. The books weren't always right. And those that were right didn't go far enough. The book on electricity,

for instance, showed how to make a magnet with a piece of iron, a twisted wire, and an electric current, but it didn't tell how the magnet worked. What were those magic fingers that reached out and held other metals to it? And all the books on botany he could find never explained how a plant could multiply itself 3000 times.

Because of his poor eyesight and growing disgust for the printed word, Charles read very little. But early in the year of 1896 news from Germany of a great scientific discovery began filling the pages of every newspaper and magazine. A physics professor, Wilhelm Röntgen, working in his laboratory at the University of Wurzburg, made an accidental discovery that opened a whole new world to science and medicine. Many scientists knew that a Crookes tube, a pear-shaped vacuum tube of glass having a cathode in one end and an anode in the other, would glow when a high voltage current was applied to it. Röntgen, in order to see the glow better, enclosed his tube in a black paper box. By accident he had left a sheet of paper coated with barium platino-cyanide lying on a nearby table. He noticed that when he applied the current to the tube in the black box, the sheet of paper began to glow. Holding up a book between the box and the paper, he saw in shadow on the paper the printing in the book. When he held his hand between the box and the paper, the bones appeared outlined on the screen. He called the invisible rays passing from the tube to the screen X rays. Within four days after his reports on his experiments were published, X ray was used in America to find a bullet in the calf of a man's leg.

The reports on X rays fascinated young Kettering, and he pored over them many a night by the pungent light of a coal-oil lamp. He began to think he might study to be a physics professor if he ever got to college. Of course, if

none of the teachers at Wooster knew more than Professor Budd about why a person can see through glass and about the magic of a magnet, then perhaps he had better be a blacksmith.

At recess one day a boy brought him a handbill his father had picked up in Loudonville.

SANTA CLARA COUNTY ON WHEELS!
ALL CITIZENS ARE INVITED TO AN EXHIBITION OF FRUITS
AND VEGETABLES GROWN IN CALIFORNIA
A RAILROAD CAR FILLED WITH PRODUCTS FROM THE LAND
OF SUNSHINE!
FREE! COME ONE, COME ALL!
FRIDAY MORNING AND AFTERNOON ONLY
AT THE
RAILROAD SIDING—LOUDONVILLE DEPOT
ALSO ON EXHIBIT
X-RAY MACHINE
CALIFORNIA LAND AND FRUIT GROWERS ASSOCIATION

"An X-ray machine!" breathed Charles. "I've got to see it."

"But it's during school hours," the boy pointed out.

"I know," he drummed on the desk with his long fingers. "If I dismissed school after recess, the little ones could go home and the older ones could walk with me to Loudonville."

"Would you darst?" asked the boy, his eyes rounding.

"It's educational," Charles told him.

Accordingly after recess on Friday he sent the younger children home. With ten of the older boys and girls he walked the five miles to the Loudonville station.

The purpose of the exhibit, he found, was to entice

farmers to emigrate to California. He didn't even glance at the exhibits of mammoth fruits and vegetables but went straight to the X-ray machine and stayed there until the exhibit closed. He held his hand between a lighted tube and a screen and saw his bones. By standing on one foot and holding up the other, he could see the bones in his foot inside the shoe and the nails the cobbler had used to hold the sole on. One by one his students joined him, looking at their own bones and wanting to know how the machine worked.

The men with the exhibit finally asked Charles and the pupils to leave. They had to take the car on to Mansfield for a showing on the next morning.

Sunday morning found Charles in church, true to his promise to his mother. Sitting on the unyielding wooden bench, Charles let his mind wander back to the X-ray machine. Could a machine be made big enough, he wondered, to show a man's entire body? Suddenly he became conscious of something the minister was saying. He sat straighter as he listened closely.

"If the Lord had wanted the human eyes to see through boards and flesh," he was saying, "man would have been born with the eyes to do it!" He pounded on the pulpit. "The very idea, taking innocent young children to witness such an instrument of the devil."

Charles could hardly believe what he heard. But there was no doubt about it. The preacher was glaring right at him. Right after the service the president of the board of education buttonholed Charles.

"I understand that you not only took the children to see the exhibit in Loudonville, but you also dismissed school to do it."

"I did," said Charles.

"And you didn't ask permission?"

Charles stared at the man. He clamped his lips shut to keep from saying what he was thinking.

"We'll have to take this up at the board meeting," the man continued.

Charles turned and walked away, his mind a mass of angry thoughts. That pompous old preacher, sticking his nose in where he had no business! And if he was such a benighted fool as to call one of the greatest discoveries of the nineteenth century a work of the devil, he had no more business standing up in a pulpit than a donkey had! Charles stalked along kicking at stones and bits of stick in the roadway. Those fool farmers would have no more sense than to believe that preacher!

"Well, let them fire me," he muttered. "I've done a good job with their darned old school and if that's all the appreciation good work gets—"

Charles went to school the next day and taught as if nothing had happened. But he knew and the students knew that the whole community was taking sides over the X-ray-machine trip.

On Thursday night the board held a special meeting to decide what to do about the teacher. Among a number of parents who attended the meeting was the richest farmer in the community.

After the minister in a blood-and-thunder speech had requested the board to fire Charles, the wealthy farmer got to his feet.

"I don't know much about this X-ray-machine business," he told the board, "but I do know that my two boys have learned more and faster since that young man came here than they ever did before!"

The board members considered the words of the man of

God and the man of wealth. They not only voted to keep Charles in his job but also rehire him for the following year.

Charles, however, told the school board that he would not return. He was going to college.

The catalog of the College of Wooster for 1896 gave expenses as fourteen dollars a term for tuition, five dollars a term for library and gymnasium fees, and board and room for boys in private homes, two fifty to three dollars a week. Books were extra but secondhand books could be had at the college bookstore. Charles had saved enough to pay for tuition. He hoped to get a job to earn his room and board.

One thing stood in his way. A knowledge of Greek was required for entrance. He had had four years of Latin in high school, but he had taken no Greek. He could, however, take a summer session at Wooster to make it up. When the school year at Bunker Hill ended, Charles got Adam to drive him to Wooster.

He found that college life was even more pleasant than he had imagined. He made friends easily even though he had little time for anything but work.

One boy became his particular friend. Lyman Knight was taking Greek, too, so he could enter Wooster in the fall term. The two studied together in Kettering's room, shouting aorists and conjugations and practicing aspirates until they knew them forward and backward. One day when Lyman appeared ready for an afternoon's study, Charles was lying on his stomach on the bed, groaning.

Lyman hurried to the bedside. "What's wrong, boy? Stomach upset?"

"No," Charles groaned. "It's my head. I've got such a headache I think my head will fly off."

"What caused it, do you suppose?" Lyman asked.

"I don't know. I've been having them now and then all summer but never anything like this."

"Maybe you should go to the doctor," Lyman suggested. "Can't afford it."

"Want a cold towel on your head?"

"Yes."

Lyman dipped a towel in the water pitcher and wrung it out. He laid it across the hot forehead.

"Thanks; that feels good," Charles told him.

That day they learned their declensions with Charles on the bed and Lyman changing the towel as soon as the coolness was gone from it.

The headache persisted. Sometimes it left for a few hours, but whenever Charles picked up a book to read, it returned viciously. Suspecting that the headaches came from his eyes, he decided that when he went home he would see about having his glasses changed.

One day when Charles came to his boarding house from his class, he noticed a catalog lying on the mail table. *The Ohio State University*, he read.

Charles had never heard of The Ohio State University, but he picked up the book and started to leaf through it. The catalog was three times as thick as Wooster's and as he turned the pages, he saw it was because the school offered more courses.

One section was headed Electrical Engineering. He looked at it in amazement. Did a college really teach things like electricity? He sat down, fascinated. In spite of the hot pains that began to knife into his head, he read on. Imagine! There was even a course in blacksmithology!

"Charlie!"

He looked up and through a blinding kind of fog saw his

brother Adam. "What are you doing here?" he asked bluntly.

"I've come to fetch you home," Adam said.

"Fetch me home?" echoed Charles, getting painfully to his feet. "What for? Is someone sick?"

"You are," Adam said. "Your Greek teacher wrote us about your headaches. Charlie, you're sick and you've got to come home to get some help."

"I can't go home. I haven't finished the course."

"That doesn't matter. Dad said to bring you home today."

"But there's three weeks left in the term. If I go home now," Charles explained, "I won't get credit, and I have to have the credit to enter college in the fall."

"Your health is more important than college," Adam said. "Now get your suitcase before I lose my temper."

Charles would have put up a better fight, but the pain in his head was so blindingly violent that he could summon no spirit. He followed Adam dejectedly to the buggy and lay with his head on the back of the high leather seat. As the horse jogged steadily out of Wooster onto the Loudonville road, he pulled the catalog out from his pocket.

"Adam, look up the entrance requirements in this book, will you? I have to know something: do I have to have Greek to enter The Ohio State University?"

Adam took the book. "Why, that's at Columbus," he said. "That's entirely too far away. You couldn't even drive there. You'd have to go on the train."

"Look it up, will you?"

They jogged along silently while Adam thumbed the pages. "Here it is," he said finally. "Want me to read it to you?"

"Yes, yes!"

Adam began to read. "Entrance requirements. College of Arts and Sciences. English, four years."

"Is there a College of Engineering?" Charles interrupted.

"Let's see. Engineering. What kind of engineering? There are a whole bunch of them."

"Electrical."

"Electrical Engineering. English, four years, mathematics, four years, including algebra, solid geometry, trigonometry."

"How about Greek?" Charles asked impatiently. "Do I have to have Greek?"

"It says Latin or Greek," Adam told him. "Four years of Latin or two of Latin and two of Greek."

"Then that's where I'll go this fall," said Charles. "I'm going to be an electrical engineer."

But he didn't go to Ohio State that fall. When the cold-towel applications that Emma and Daisy took turns putting on his eyes failed to stop the headaches, Emma drove him to Mansfield to the eye doctor.

He examined Charles, shook his head, and called Emma into the examination room. "Both of you must know," he told them, "that this young man's eyes have been given a severe strain. I am not at all sure that I can save his vision."

"What?" Charles gasped.

"It's that serious," the doctor warned him. "I am going to give you some drops to put in your eyes every day. You must stay in a dark room and under no circumstances do any reading. After a month I will examine you again. But I can promise you nothing."

The boy sat glumly beside his older sister on the trip home. "What will I do if I go blind?" he asked plaintively. "If I can't see, I can't go to college. And if I can't go to college, I might as well be dead."

Emma patted his hand. "Maybe your eyes will get better," she said.

"They just have to." He slid down on the leather seat and

rested his head on the back, keeping his eyes closed all the way home.

At home he stayed in the house with the shutters closed for several weeks. Then, beginning to feel better, he ventured out into the shady wood and finally into the sunny fields to help with the harvest.

But in the autumn when colleges all over the state began, his suitcase stayed on the shelf. Christmas came and went. His eyes improved, but he still could not read without starting the headaches. Winter wore away, and one sharp spring morning he found an arbutus blooming in a snowy low place in the woods. The flower reminded him of Trixie, and he put the flower on her grave.

The same afternoon David invited Charles to ride along with him to the post office. While his brother went to get the mail, Charles walked down Main Street. In front of the bank he ran into one of his old teachers, Neil McLaughlin. It was he, Charles always said, who first taught him to think in and around and through commonplace things.

"So the *Mayflower* brought the Pilgrims to America," he would say in history class. What kind of ship was the *Mayflower*? How many tons? Where was she built? Who was the captain? How many passengers? What kind of clothes did they wear? What did they eat?" Much of Kettering's teaching was patterned on his memory of Neil McLaughlin's history classes at Big Run School.

The two shook hands. "Say, Charlie," Neil exclaimed, "this is a real coincidence. I've been wanting to talk to you. If that old telephone of yours was attached to something, I would have called you from the drugstore. This saves me a trip."

"That so?"

"Yes. How are you feeling? I heard you were sick."

"Better now. Almost like new."

"Fine! I'm glad to hear it. Reason I wanted to see you, I am going to give up my school at Mifflin next week. I'm going to work in the bank here. I was wondering if you would want me to recommend you for the job?"

Charlie's face brightened. "Would you?"

"I certainly would," McLaughlin answered heartily. "It's a two-room school, bigger than Big Run or Bunker Hill. I have the upper grades. Another teacher has the lower grades. Actually, you would be the principal."

"How far is Mifflin?" Charles asked.

"Some ten miles."

"I'd like that fine," he told McLaughlin.

Charles began teaching the next week at Mifflin. He finished the school year and returned for the following term.

During the second year, Emma taught the lower grades in Charlie's school and the two roomed in the same house.

Charles, almost twenty-two now, made two new friends in Mifflin. Much of his spare time he spent in the back room of John Robinson's drugstore, tinkering with several dry cells, a doorbell, and a few turns of copper wire. Robinson had almost as much interest in electricity as Charles, and the two spent many a pleasant evening with their experiments.

The other friend was a wagonmaker, Hiram Sweet. By day he turned out wagons and buggies for the folk of Mifflin; at night he worked on his inventions. He had made the cash register that Robinson used in his drugstore.

One cold February day Charles dropped in to inspect a perpetual calendar Hiram had just finished. "How did you ever figure this thing out?" he asked.

Hiram showed him how it worked. "I imagine this calendar will mark a sad day in our country's history before we

are much older," he observed, as Charles peered into the calendar's insides.

"How so?"

"The Spanish blew up one of our ships in Havana harbor yesterday. The *Maine*."

"That so? What's this little wheel for?"

"It turns one revolution every seven days and changes the days of the weeks. It means war with Spain."

"That's darned ingenious, Hiram. How did you figure that out?"

"What else can we do? We have to show those Spaniards they can't get away with killing our people. More than two hundred and fifty died in the explosion."

"I mean how did you figure out that wheel?"

Hiram looked at the lanky teacher with his long fingers poking away at the calendar.

"You don't give a darn whether we get into war or not, do you?" Hiram asked.

Charles shook his head. "That's a long way from here," he said. "What I'm interested in is how you know how to go ahead with these ideas of yours."

Hiram laughed. "All day I work here in this shop," he told him, "and when I have finished, then I work the rest of the day on the head of Hiram Sweet."

"I'll remember that," Charles said seriously.


He was sitting in John Robinson's back room with his feet on the table and a cap pulled down over his eyes the April day that war with Spain began. When Dewey sank the Spanish fleet in Manila Bay the following month, he was lying at home in bed with one of his headaches. When the war ended in August, he was counting the money he had saved to go to Ohio State. He had enough to pay the first quarter's tuition and a little besides. Room, board, and books

and the money for the second and third quarters he would have to earn when he got to Columbus.

"Do you have enough?" Daisy asked him when he came out of his room.

Charlie shook his head. "No, but I am going."

3

 Except for his visit to the railroad freight car to see the X-ray machine Charles had never been inside a train until he took the smoky, dirty ride from Mansfield to Columbus one hot September day in 1898.

A tall, lanky youth of twenty-two, he wore a derby hat, a dark-gray wool suit with padded shoulders, a striped shirt with stiff collar and cuffs, heavy wool socks, and sharply pointed shoes. He had thirty-five dollars in his pocket.

In 1898 that was a considerable sum. Sugar sold for four cents a pound, eggs at fourteen cents a dozen and potatoes at thirty-five cents a bushel. A turkey dinner in a first-class restaurant could be had for twenty cents. Men's suits sold for ten to seventeen dollars, and a pair of shoes was two dollars and a half.

Carrying his suitcase that held his other suit, two shirts, three suits of underwear, and five pairs of hand-knitted socks, Charles took a horsecar to the university. At the registrar's office he signed up to take chemistry, drawing, rhetoric, German, and mathematics in the electrical-engineering course. He also discovered much to his dislike that all freshmen had to take cadet service. Tuition for the first quarter was fifteen dollars with an additional two dollars and a quarter for laboratory fee. The cadet uniform cost fourteen dollars. That left him three dollars and seventy-five cents to last until he could find work.

He could get a bed at the Y.M.C.A. for thirty-five cents and he allowed himself thirty-five cents a day for food. A breakfast of oatmeal and milk cost a nickel. Three slices of cold meat and two buns at a nickel made his lunch. For twenty-five cents he could get a hearty supper. He could get along for three or four days, he figured. By then he would have to find some kind of job.

The first day of classes he struck up an acquaintance with a chap named Harry Smith, who was in his set of four in cadet battalion.

"Got a place to room and board yet?" asked Harry.

"Not yet."

"Why don't you come out where I live? The landlady's name is Mrs. Leonard Young. Food's good. Beds are soft."

"How much?"

"She charges two dollars and a quarter a week. You can't beat it. Believe me, I've looked around."

"Thanks," said Charles. "I believe I'll go out and talk to her."

After drill he walked with Harry out to meet Mrs. Young, whom he liked at once. The motherly woman instinctively liked the awkward, gangling boy and made room for him in her establishment.

Before the day was over, he looked up the maintenance superintendent of the university. Because he had a knowledge of carpentry gained from his father, he came away with a job that would enable him to pay for his board and buy his books.

Although he slipped easily into the college routine, he heartily disliked one part of his day. Lugging a rifle up and down the field in drill was not his idea of pleasurable activity. Maybe there was a way to get out of it.

By inquiring around he found that the only students ex-

cused from military drill were members of the band. Now there was an idea!

Charles had learned to play the violin at home. Knowing that a stringed instrument had no place in a band, he cornered a boy in a band uniform one day.

"What instrument is the scarcest in the band?" he asked.

"The director is always howling how nobody plays the clarinet anymore."

"Would I be able to borrow one from him, do you suppose?"

"Sure. He's got all kinds of instruments to lend."

The next afternoon Charles answered a knock on his door. Harry, in his cadet uniform, popped in. "What's the matter? You sick?"

"No."

"Then why weren't you at drill this afternoon?"

"I've been excused," Charles told him. "I am now a member of the Ohio State University marching band."

Harry collapsed on the bed.

"I didn't know you were musical," he said. "What band instrument do you play?"

"Right now I don't play any," Charles told him. "But this afternoon as soon as I finish my German, I am learning the clarinet."

"Well, I'll be darned."

He made progress on the clarinet and in his classes. Rhetoric for him was easy. Compared with the Greek he had studied at Wooster, German seemed simple. Mathematics had been a favorite subject since Big Run school days. But he ran into a little trouble in chemistry.

In the laboratory one afternoon he reported to F. O. Clements, the graduate assistant in charge, that dirty brown

is the color of the compound obtained by mixing oxalic acid and potassium permanganate.

Clements looked up at the tall freshman through shiny eyeglasses and shook his head. "It's wrong, Mr. Kettering."

Charles returned to his desk and performed the experiment again. Back he went to Clements, test tube in hand. "It's a dirty brown," he repeated.

Clements took the test tube, shook it, sniffed it, and handed it back. "Let me see you perform this experiment," he said. Going to the supply window, he asked R. M. Royer, the assistant in charge, for more chemicals. Royer frowned. "Mr. Kettering, your chemistry bill is twice as high as that of any of the others in the lab. What do you do with the stuff? Eat it?"

Charles threw back his head, laughing. "I do the experiments."

"But the others do, too, don't they?"

"Yes. But the book and the prof both say that when you put certain chemicals together, they act a certain way. Now I want to be sure they do. So I do the experiments maybe a couple of times or so, just to see whether maybe they might act different."

Royer looked sharply at the young man. "So you think the books are wrong, do you?"

"Not necessarily. But I like to be sure."

"You know it's costing you, don't you?"

"I know."

Back at his desk, Charles poured one cc. of oxalic acid into a test tube and added three crystals of permanganate. Shaking the tube, he held it up for Clements to see. "There you are, sir, dirty brown."

"Add the rest of your permanganate," Clements directed.

When Charles poured in the rest of the crystals, the compound in the tube turned to bright purple.

"That's your answer," Clements said.

"But the book doesn't say how much permanganate to use," Charles protested. "I did what the book said and got a dirty brown. The book should say exactly how much to add."

Clements looked at the rawboned freshman with interest. "The fellow who wrote the lab manual assumed you would add what the supply clerk issued you. But you might have a point there." He started to walk away but returned. "Not many freshmen start out by finding the book is wrong, Mr. Kettering."

"People write books. People make mistakes."

"Let me watch you do your next experiment," Clements said.

From that day, the two began a friendship that lasted until Clements died.

Toward the end of his freshman year, Charles' eyes began to bother him again. The headaches returned, but by ignoring the pain and having Harry Smith read his lessons to him, he finished the year.

After a summer at home on the farm, he returned to Ohio State to begin his sophomore year. But within two weeks the headaches began. He knew that he could not hope to go through the year in spite of all the help his friends could give him.

The day he packed to go home, his spirits sank lower than they had when he first learned he might lose his sight.

"I know this is a great disappointment to you, Charles," Mrs. Young comforted as she helped him pack. "I do hope you will be able to return to us soon."

Charles snapped his suitcase shut. "If I can't come back

and finish college, Mrs. Young, I hope the train goes off the track and kills me."

"Oh, don't talk that way," his landlady protested. "Surely it isn't that bad."

"For me it is," he replied.

The train did not go off the track but arrived safely in Mansfield, where David was waiting with the buggy to take Charles home.

All autumn he hung around the farm, moping. Christmas came and went, but the headaches continued. The arbutus bloomed early in the spring and faded. Spring beauties and violets paved the woods and died, and May apples raised their green umbrellas. Still Charles could not read.

One warm day in June, he told his mother if he didn't get better soon, he felt like climbing the highest tree in the woods and jumping out of it.

"Why don't you walk over to Mifflin and visit your friends for a little?" she asked.

The idea appealed to him. He packed a bag and set off the next morning. He visited John Robinson for a while, and then dropped in on Hiram Sweet. Outside Hiram's shop a crew of workmen was making a great to-do with posthole diggers, reels of wire, and poles.

"What's going on?" Charles asked.

"Mifflin is getting telephones," Hiram told him. "Star Telephone from Ashland. They've been working here for the last six months or so."

"Wonder if they need any more help."

"Say, that might be good for you," said Hiram. "Working on that job would toughen you up. Might help your eyes."

"I believe I'll look up the foreman," Charles said. He did and was hired on the spot at seven dollars a week to dig post-holes.

Digging holes for telephone poles, he discovered, was no easy job. The holes, each about one foot in diameter, had to be anywhere from three feet to six feet deep, depending on the height of the pole. He started out on four-foot holes. The first day he dug two.

Toward quitting time the foreman came by. Looking down to the bottom of the first one, he exploded. "You don't have to polish them like they was diamonds!"

"Whatever I do," Charles told him, "I do right!"

Within several weeks he became foreman of his gang. Although his temper flared out when he found poor work or lazy workmen, his men respected and liked him.

One day about lunch time a bewhiskered fellow with a weathered cap and shabby overalls walked up to a group of diggers. "Could anybody spare me a bite?" he asked.

Charles looked him up and down. "I'm just about to have my lunch in that restaurant over there," he said, nodding at a shop across the street. "You are welcome to come along with me."

The tramp followed him into the restaurant. They sat at a marble-topped table and had stewed chicken and dumplings. After apple pie and coffee, Charles lit a cigar and gave the tramp one. "Wouldn't you like to have a job and be able to buy your own lunch?" he asked.

The tramp agreed somewhat reluctantly that he would.

"I'll take you on as a digger," Charles told him. "A dollar a day."

He took the fellow back to the job, gave him a posthole digger, and showed him where to start.

An hour or so later he came back to check on the tramp. "How's it going?" he asked.

The tramp shot him a baleful look. "You need dynamite to make a dent in this goldarned dirt!" he said. He showed Charles his hands. Blisters covered the palms.

Charles inspected the jagged depression the tramp had scoured out of the earth. "Let me show you what a good posthole looks like," he said. Picking up the digger he set it to biting into the ground. "The idea is to make this hole as smooth and round as a worm," he explained, "and absolutely perpendicular." As he talked he began to turn the tramp's jagged hole into a smooth, even tunnel. "It's fun to see how smooth you can make it."

"Let me try." The tramp took the digger and started to work. After a moment Charles returned to his own job.

The tramp became the best posthole digger the crew had. One day he looked Charles up. "You know, I was ready to quit the day you showed me that digging a posthole can be fun," he said. "You are the only person I ever knew who told me work can be a pleasure. If I had met you earlier, I never would have been a bum."

A month or so later Charles was promoted to putting crossarms on the poles. He worked with easygoing Mont George as a partner.

One day when Charles climbed down from putting up a crossarm, he found the foreman waiting for him. "You Kettering?"

Charles nodded.

"Like to ask you something. Do you think that you could install a telephone exchange?"

Charles scratched his head. He knew as much about installing a telephone exchange as he did about high finance, but saying no never got anybody anywhere. "Reckon I do," he drawled. "What I don't know I can learn."

So Charles left the road and was put in charge of installing the Mifflin exchange. He knew something about wiring and a little more about how telephones worked. In response to a telegraphed request to the Kellogg Switchboard and Supply Company, for an installer's manual, he received a copy of

American Telephone Practice, by Kempster B. Miller, a book filled with step-by-step diagrams and explanations. As soon as he glanced through it, he knew that with its help he would probably be able to figure out how to put in the exchange.

"The reason this thing seems hard," he explained to Mont George one night as he pored over the next day's job in the manual, "is that I don't understand it. When I do understand it, then it won't be hard."

He began studying the manual at night and putting to practice what he had learned the next day. Later on, he was able to work ahead from his own knowledge and experience, but now and then whenever he was in a difficult spot, he returned to the manual. He gained the reputation of being an excellent exchange installer, so that as soon as the Mifflin exchange was completed, he went to work putting one in at West Salem, a little village near Ashland.

In Ashland one day in the summer—it was 1900 and William Jennings Bryan had just been nominated for President—Charles climbed a cherry tree to clear a line that was being strung from Ashland to West Salem. As he hung in the tree straightening out the line, the tinkling notes of a piano came from an open window of a nearby house. The song was a new one he had learned at Ohio State. He hummed now as the melody lilted along.

*"Oh, the moonlight's fair tonight along the Wabash.
From the fields there comes the breath of new-mown hay—*

"Hear that music?" he called to Mont George on a pole some twenty yards away.

"Yep. That's Olive Williams playing."

When the two met on the ground later, Charles asked, "Who's Olive Williams?"

"She's a girl who lives in that house over there."

"Pretty good piano player."

"Yep. She plays the organ in the church down on the corner, too."

"She nice looking?"

Mont George grinned. "You aren't getting interested in her, are you, fellow?"

Charles blushed and dropped the subject.

Two weeks later Mont began making test calls from the almost-finished, exchange at Salem. Charles, working on the switchboard, heard him say, "That you, Olive? Mont George. We're testing. Can you hear me? Say, Olive, there's a big, awkward guy here who's my boss, he heard you playing the piano the other day. He thinks you play quite well . . . up in the cherry tree . . . Charles Kettering . . . Would you like to talk to him? Here, Charles," Mont held out the receiver, "Olive Williams is on the line. Say something to her."

Charles took the telephone. "Huh—huh—hello," he said.

"Hello, Charles," said a clear, ladylike voice on the other end.

"Uh—we're testing the line. Can you hear me?"

"I hear you perfectly," Olive answered. "Can you hear me?"

The next Sunday when Charles went to church, he did not go to hear the minister nor to cleanse his soul. He went to see the organist, a dark-haired, brown-eyed girl named Olive Williams.

After the service he waited for her and introduced himself.

When they parted, Charles walked down the brick sidewalk as if he had springs in his feet. He liked the looks of Olive Williams, and she—well, she had invited him to call.

He would have to have some new shoes and a haircut and—should he take her a bouquet or not?

With a part of his mind he worried about what he would say when he went to call on her, but most of his thoughts went to problems he was working on for the Star Telephone Company.

In 1900 it was a nuisance if you lived in the country not to have a telephone, but it was almost as great a nuisance to have one. The telephone consisted of a wooden wall phone with a crank on the side and a dry-cell battery and magneto inside. Every time anyone on the line received a call, the bell rang in every house along the line. Although each subscriber had his own combination of short and long rings, the temptation to listen in on other conversations was rarely resisted.

"Why couldn't we install a central battery system here in town with enough juice to ring each telephone individually?" Charles asked his boss.

"Can't be done," the boss told him. "You know now when electric current goes along a wire, the wire builds up a resistance and turns the electricity into heat? We couldn't have batteries strong enough here to carry the electricity out in the country. Some of those lines are twenty miles long."

"Why couldn't we install relays and impedance coils at intervals along the line to take the resistance off the wire?"

The boss looked at Charles with surprise. "It might work," he said. "We never thought of that. Why don't you try it?"

With pencil, drawing paper, and what he had learned on the job and in the back room of John Robinson's drugstore, Charles figured out a system of relays, which, coupled with stronger batteries at the central station, would allow enough

current to pass along the line to ring each subscriber separately.

With drawings in hand he went to sellers of relays and impedance coils. "Nobody makes a coil like your drawing," the dealers told him.

"Then I'll make my own," said Charles.

He bought relays and unwound yards and yards of wire coils. Then he began to wind a coil to his own specifications. Halfway through the first one he threw the coil down in disgust. It would take him a whole day to wind one. He would be half a year older before he had enough coils for the entire system. Was there some mechanical way of winding the wire? His mind went back to the bobbin on his mother's sewing machine. Why not? He hurried out, bought a second-hand machine, and turned out enough coils for the whole system in one day.

When he completed installing the relays along the line and added batteries in the central station at Ashland, the system worked perfectly. Officials of the telephone company looked on Charles Kettering as a rising young man.

For several weeks the system operated flawlessly. Then one afternoon all the telephones on the line went dead. A repair crew started out to look for the trouble. Before they could find it the telephones were all right again. The next day the same thing happened, and the next and the next.

Charles happened to be in his boss's office one afternoon when a call came in from the central operator that the lines had gone dead.

"That's the end!" the man exclaimed. "We will just have to go back to multiple rings again. I'm sorry, Mr. Kettering, but your system is no good. The lines are out of service about two hours every day."

Charles asked the boss to let him see whether he could

find the trouble. Borrowing a buggy, he drove out to the middle point on the line. As soon as the lines went dead, he started testing individual telephones. He found nothing wrong at the first house, nor at the second nor at the third.

At the fourth house the owner took a long time to answer the door. He turned out to be a yawning elderly gentleman in stocking feet. Charles told him he wanted to check his telephone.

"Come on in," the man yawned. "I was taking my nap. Wait till I get my glasses on so I can see you."

Charles followed the old fellow into the parlor and watched him shuffle over to the telephone and unhook his steel-rimmed spectacles from the wires leading out of the binding posts.

"Do you always put your spectacles over those wires when you take your nap?" Charles asked.

"Yep. It's handy."

"And you take a nap every day from about two to four," Charles went on.

"Yep."

"You will just have to find another place to put your glasses," Charles told him. "You have been shorting out every telephone on the line."

Charles called on Olive Williams many times during the summer of 1900. Often they went for walks, he stalking along silently while she chatted on about wasn't it terrible how the British were treating the Boers and would Bryan be elected and on what day did the nineteenth century end and the twentieth begin: had it been January 1, 1899 or January 1, 1900? He usually answered her in monosyllables because he really didn't care at all who was President or whether the United States annexed the Philippines.

What he really cared about was sitting beside Olive on

the piano bench while she played popular songs like "Just Tell Them That You Saw Me," "There'll Be a Hot Time," and "I Don't Want To Play in Your Yard." Often he joined with her in singing "The Bowery" or "Little Annie Rooney." When she started on the "Moonlight Sonata" or a Chopin mazurka, he sighed contentedly and sat wordless until she had finished.

One night he said to her, "I will miss your music when I'm gone."

"Gone? What do you mean?" she asked.


"I want to go back to Ohio State this fall and finish my education," he told her. "Will you write to me?"

"If you write to me first," she replied.

All evening he had been wondering whether if he kissed her, she would slap his face. He tried it.

She didn't.

4

 John D. Rockefeller was the richest man in the United States in 1901. Charles F. Kettering was just about the poorest.

Determined to finish his schooling at Ohio State even though he was now twenty-five and only a sophomore, he gave up his job with the telephone company and returned to Mrs. Young's boardinghouse on Seventh Avenue.

He found that Harry Smith had left Mrs. Young's, but he quickly made friends with Carl Leibold and Herbert Bostater, both electrical engineering students who roomed there.

Much of the time the three studied together, and both Carl and Herb frequently read the lessons to Charles to save his eyes. They had improved greatly during the two years he worked for the telephone company. With his new glasses he could now see quite well except for close work.

Because the engineering drawing requirement for graduation was impossible for him to meet, he asked to be excused from the drawing classes. A faculty committee decided to allow him to attend the classes without doing the drawings provided he made top grades in courses he took as a substitute credit.

These were quantitative analysis in his sophomore year and third-year chemistry in his junior year. Both years his teachers noticed that his experiments were frequently set up

differently from those in the book, but they got the same results.

During every vacation he worked for the Star Telephone Company. He had to have money, for one thing, and being near Olive Williams was becoming almost as necessary. In his own mind Charles had decided that he wanted to marry Olive just as soon as he finished school and saved enough money to furnish an apartment.

One winter vacation he heard that the owners of an Ashland factory had installed a new boiler room to furnish power for the factory, but the men in charge complained that they could not keep the pressure up.

The plant owners called in steam experts who recommended an expenditure of several thousand dollars to increase the height of the chimney. They had decided to go ahead with the expense when Charles arrived at the factory and asked permission to visit the boiler room.

When he tried to open the door, he decided it was locked. "May I have the key to the boiler room?" he asked the office manager.

"It isn't locked," the man told him. "It just opens hard. Pull."

He wrenched the door open. When he stepped inside, the door banged shut with power.

Charles went back to the office. "I know why you can't keep pressure up," he said. "You have that room sealed up so tightly that no air can get in. If you prop that door open and let some air in at a window, you'll keep your pressure up without any trouble."

The plant owners followed Charles' suggestion and saved several thousand dollars. "Sometimes these expensive experts don't know as much as a fellow with plain, ordinary horse sense," he told Olive that night.

During Charles' sophomore year President McKinley died after being shot by Leon Czolgosz, and Theodore Roosevelt became President. A woman went over Niagara Falls in a barrel and survived. The army discontinued the use of homing pigeons because the telegraph had become practical. The player piano became so popular that music teachers everywhere began to protest against mechanization.

Olive, in a letter, told Charles about a cartoon she had seen in *Life*. A little boy rushed up to his mother and shouted, "Oh, mama, mama, I just saw a man playing a piano with his *hands!*"

During Charles' junior year, prices soared. Sirloin steak went up to twenty-four cents a pound; lamb chops and ham were eighteen cents. A suit now cost him twenty dollars and shoes, five dollars.

In Pittsfield, Massachusetts, President Roosevelt was injured when a trolley struck his carriage. In Detroit, Michigan, a man named Henry Ford drove a racing automobile around a one-mile track in one minute, one and a half seconds.

When Charles was a senior, an automobile crossed the continent from San Francisco to New York under its own steam in fifty-two days. Carrie Nation was arrested in Washington for giving a speech in the Senate gallery. Two boys from Dayton flew an airplane at Kitty Hawk, North Carolina, and Madame Curie in France discovered radium.

As always, Charles had money problems. But once, during his senior year, he earned enough money in one night to pay all his expenses for one quarter.

When a telephone cable developed trouble in a section near the edge of Columbus and the best trouble shooters of the system could not find the cause, the company service chief called the university electrical engineering department

for help. Knowing that Charles had worked for the telephone company, the department head turned the problem over to him.

In physics laboratory he had been studying the Wheatstone Bridge, a device for measuring resistance in an electric wire. It had occurred to him that such a tool could be used to find trouble in a cable. Here was his chance to try.

Taking a Wheatstone Bridge and a galvanometer from the department, Charles went with the lineman out to the area where the trouble had developed.

"It could be anywhere along this line for thirty miles," said the supervisor.

As soon as the sun went down and the wires cooled, he began testing. Climbing up a pole, he attached the Wheatstone Bridge at a check point. After measuring the resistance by means of the bridge and the galvanometer, he climbed down and went on to the next check point, followed by the supervisor and squads of repairmen.

Finally near midnight, he climbed down a pole and said, "The trouble is between this point and the last one I checked."

"That narrows it down to only a mile," the supervisor said. "That's some progress."

"Is there a cable splice between here and the last point?" asked Charles.

By lantern light the supervisor checked his charts. "Yes, there is one in pole 2785."

"Let's check it first," Charles suggested.

"I think it's a waste of time," the supervisor objected. "That splice was made by our most experienced man. It couldn't be faulty."

"Let's check it," insisted Charles.

He and the supervisor climbed pole 2785 in the light of

lanterns held by workmen. With his spikes biting into the pole and leaning back on his belt, Charles took out his pocket knife and cut into the lead sheathing of the cable. "Look," he said.

The supervisor held his lantern close. A trickle of water ran from the cut into his hand.

"I'll be doggoned," the man said softly.

"Want me to splice it for you?" Charles asked.

"Can you?"

"Sure."

For finding the trouble and splicing the cable, he was paid \$125.00. "It's a lot of money," he told Olive in a letter, "for losing a night's sleep."

Two weeks before commencement he found a note on the mail table asking him to call at the office of the physics professor, Albert D. Cole. He went at once.

"Come in. Sit down," Cole said when Charles appeared in his office doorway. "I have something here that I think might interest you." He picked up a paper lying on his desk. "Yesterday I received a letter from a former student of mine at Denison University. His named is Edward Deeds. He is plant manager of the National Cash Register Company in Dayton. He needs an electrical engineer on his inventions staff. From what I know of you, I am sure that you are just the man he is looking for."

Charles blinked. "I'm not looking for a job," he said. "I have one waiting for me at the Ohio Telephone Company in Mansfield."

"That's fine," Cole said. "But I believe you should look into this position."

"My home is not far from Mansfield, and I have—" He gulped and blushed. "I keep company with a young lady in Ashland."

The professor smiled. "That's fine, Mr. Kettering. I would not insist if I did not know what a rare opportunity this is. I do wish you would go to Dayton and talk with Mr. Deeds before you decide."

Charles hedged, "I don't want to seem unappreciative, Dr. Cole, but—"

Cole tapped the letter with a long forefinger. "Mr. Kettering, the telephone has a great future for any young man, I am sure. But I would like to point out that where there are scores of telephone companies in this country, vying for the customer's business, the National Cash Register Company is the foremost factory of its kind and almost the only one. Men come from all over the world to study the progressive methods that have been inaugurated there. Believe me, Mr. Kettering, I would think three times before I turned down such an opportunity!"

"I honestly never heard of the place," Charles confessed.

"Then why don't you go down and look it over and talk with Deeds?" Cole suggested once more. "Then if you don't like what you see, you can still go with the telephone company."

"All right, Professor," Charles agreed. "I'll go."

He borrowed the train fare to Dayton from Mrs. Young and made the trip the following Saturday. The wide streets and cleanliness of the town surprised him as he took a horse car to the factory on South Main Street at the edge of town.

Each building, light-tan brick and mostly windows, sat on a landscaped lawn with flowerbeds blooming around the foundation. To Charles the factory looked more like a university than a commercial enterprise.

A receptionist in a crisp shirtwaist pointed out the office of the Works Manager. Charles stuck his head around the partition and said to the man at the desk, "Hello! You Mr.

Deeds? I'm Charles Kettering. You wanted to see me?"

Edward Deeds, at twenty-nine not much older than Charles, stood slightly over six feet tall. Built like a football player, he had straight blond hair, brilliant blue eyes, a dimple in his chin, and a pink skin that shone with cleanliness. "Come in," he said.

The longer Charles sat in Deeds' office and answered questions fired at him, the more convinced he became that the cash register company was the place for him if only he could get the job.

By the time he got back to his boardinghouse that night, he was sure he wouldn't get it. "I don't think I made much of an impression on him," he confided to Mrs. Young.

But on the following Tuesday he found a letter from the National Cash Register Company on the mail table. As he tore open the envelope excitedly, a slip of paper fluttered from it. He picked it up. It was a check for fifty dollars.

Stuffing the check into his pocket, Charles raced through the letter. His eyes skipped over the words. "Salary . . . immediately . . . school not out . . . report here two weeks . . . fifty dollars."

He let out an Indian whoop that brought Mrs. Young from the back parlor. "I got the job! Imagine, they're paying me fifty dollars! That's more than the telephone company would pay. And they paid me ahead of time. Look!" He showed her the check.

"Good for you, son."

Martha and Jacob Kettering came down from Loudonville to see their son graduate from Ohio State. Olive Williams came, too. The fifty-dollar check helped pay for their entertainment during commencement week, but it did not stretch far enough to buy tickets to the senior breakfast on commencement morning. They all ate together at Mrs.

Young's. Afterward they walked to the university, Martha and Jacob in front, and Charles, with his robe flapping out behind him, and Olive, hanging back a quarter of a block.

Charles had a question to ask Olive. "Just as soon as I get settled in my job and save up a little money, will you marry me?"

Olive laughed. "My goodness, Charles, I thought I'd never hear you say those words!"

"You mean you thought I was going to ask you?"

"Almost ever since Mont George introduced us over the telephone," Olive told him. "I think I knew it that Sunday you came to church to hear me play."

"You did?" Charles asked incredulously. "How did you know that?"

"Women know those things," she answered. "I'd love to marry you, Charles Kettering."

"Honestly?" They walked along silently for a moment. Then Charles burst out with, "What on earth do you want with a poor old farm boy like me?"

For answer she patted his hand then hurried up to tell the news to Jacob and Martha.

On July 1, 1904, a hot, sultry morning, Charles reported for work at the National Cash Register Company. Mr. Deeds took him to a section of the main building called Inventions 3, one of six departments devoted to the improvement of National products.

Inventions 3 had a large design room and experimental machine shop. Deeds showed Charles his desk and bench and then introduced Bill Chryst, who was to be his chief assistant, Bill Anderson, foreman of the experimental machine shop, and machinists Zerbe Bradford, John Lipes, and Hal Nickols. In the drafting section he met B. M. Shipley, Red Hoffer, and Bill Matthews. Electricians Harve Phillips, and

John and Frank Sheats completed the staff. Charles found he had been hired as head electrical designer to take the place of a man who was retiring.

After he shook hands with the men, he walked into his office with Deeds. "By the way," he said, pulling a scrap of paper from his pocket, "somebody here made a mistake. I received two pay checks. This one came last week." He handed Deeds a fifty-dollar check.

Edward Deeds glanced at the paper and handed it back. "There hasn't been any mistake. It has been two weeks since you were hired."

Charles gulped. "You mean I am getting fifty dollars a *week*?"

"That's what I offered you in my letter, is it not?"

Charles rubbed a thumb along the ridge of his nose. "I read the letter in a hurry," he confessed, "I thought it said fifty dollars a month."

Deeds laughed. "Don't let that get you," he warned. "If Mr. Patterson heard about it, fifty dollars a month is all you would get."

"Who is Mr. Patterson?"

"The president of the company. You will be hearing about him from everybody. Now, Mr. Kettering, let's get to work. Come over to this bench," he continued, walking to a workbench on which sat a shiny cash register. "I want you to look at this machine."

The register, ornate with fine wood carving across the top, had banks of shiny metal keys on the front. "As you see," Deeds explained, "the force necessary to operate the mechanism of the register is supplied when the operator turns this crank." Deeds punched several keys and gave the crank one revolution. A bell rang, a \$2.98 sale sign ap-

peared in the glass window at the top, and the cash drawer opened. He gave the crank a second revolution and a printed receipt appeared.

"It requires too much force on the part of the clerk to operate this machine," Deeds went on. "What we want to do is replace this crank with an electric motor. So you think you can do that?"

Charles frowned. He did not know how to electrify a cash register, but he had not known how to install a telephone exchange, either. "I think so," he said.

"Good!" Deeds exclaimed. "I think you can, too, but I must warn you, sir, that some members of the Demands and Improvements Committee will tell you that you can't do it."

Charles' eyes sparkled behind his glasses. "Committees don't worry me, Mr. Deeds. I believe that anything a man can imagine, he can do, provided he does what nature wants him to. The only problem is to find out how to do it."

"Keep up that optimism!" Deeds encouraged. "I like it. Now the very first job we want you to do before you start on the project is to put a solenoid on our number thirty-five register. Bill Chryst will bring you up to date on it."

Charles walked over to Bill after Deeds left. "Tell me a little about how a cash register works," he said.

"Sure thing, Boss," Bill replied. Charles grinned. The nickname stuck. From that minute he was Boss or Boss Ket to everyone with whom he worked. Only to his old friends and his family was he Charlie or Charles.

The old 35, he learned, was a total adder. That is, the values of all the keys pressed were added on a series of adding wheels so that the machine computed the total gross business of the day. When the keys were pressed, they were

coupled to a transverse bar which completed the operation of the selected wheels and turned the proper series of adding wheels. The extra work of turning the adding wheels was objected to by clerks. Charles was to attach a solenoid which would operate the transverse bar.

From the very first day he started out to be an unorthodox inventor. The typical inventors of the day worked in secret, fearing that others might steal their ideas. Charles called the whole staff together, presented the problem, outlined what he thought ought to be the program, and invited contributions from everyone. Nobody in the factory had ever heard of such a method before.

He was also unorthodox in that he came to the factory early, often worked through lunchtime, and stayed late.

While Charles was working on the solenoid, salesman Richard H. Grant brought an idea for a new product to the Demands and Improvement Committee. He wanted a machine that would speed up credit purchases in department stores.

Credit offices were apart from the selling floors in department stores. Valuable time was wasted in going from one floor to another for credit authorization. The problem was given to Charles.

He worked out a machine called the OK Charge Phone, a combination of telephone and solenoid stamping device. When a salesperson had a credit purchase, he called the credit office on the telephone, and the credit clerk pressed a button which operated a stamping device to indicate approval. The embossed sales slip remained as evidence that the credit was approved.

Five months after he began work at NCR, Charles had a demonstration model of the solenoid on the 35 register

ready for approval. Three weeks later the first model of the OK Charge Phone was ready.

He spent the first seven months at NCR working on projects not connected with putting the electric drive on the cash register, the job for which he had originally been hired. On February 18, 1905, Deeds relieved him of all other responsibilities so that he could devote his time to the original project.

He sat down to talk the project over with Bill Chryst. "As I see it," he began, "one problem is to determine how much torque is needed to operate the register. Then all we need to do is design a motor that will furnish the power. It will have to be a small motor that will operate under all kinds of treatment without breaking down. And it will have to come to a dead stop on completion of each full turn without excessive sparking when it makes and breaks electric current." Charles, who was sitting at his desk, slid down on his spine until he was comfortable.

Bill did the same. "Our other problem is that we sell cash registers all over the world. Here we use a hundred and ten volts, alternating current. I know of places in New York that have as many as six different kinds of current in one block. Overseas most countries use two hundred and twenty volts and direct current."

"Looks like a tough problem," Charles said.

"Nobody except Deeds and Patterson thinks it can be done."

"And Charles Kettering," said Charles. "There are no unsolvable problems, Bill. Just problems that we don't know how to solve. Believe that?"

"I'm not sure."

"Take flying, for instance," he went on. "People said for

years that anything heavier than air couldn't fly. But nobody told the birds, so they went right on flying. Then those two fellows down at Kitty Hawk, they didn't listen. So they flew. See?"

"I see."

"You know those fellows, by the way?"

"The Wright boys? Sure. Known them for years. They fly like mad every day out east of town here."

"I'd like to meet them sometime."

"I'll arrange it," Bill promised.

"Now let's get to work," Charles said, getting to his feet. "Get me some weights."

By hanging weights on the crank handle until the machine operated, he figured the horsepower he needed.

"Now another problem," he explained to Bill, "is to determine how much time the register needs power during each operation. Certainly, the motor doesn't have to run, for instance, when the cash drawer is open."

"That's good," said Bill, "because it has to have time to cool off, or the motor would burn out."

"Right. Now where would a register be used the fastest, do you suppose?"

He finally decided to use a motor that would not burn out even though the register were operated fifty times a minute. "I think that a one-fifth horsepower motor will do the work," he said. "We'll have to use a series motor because an induction motor can't give enough torque at the start."

From the supply department he procured a $\frac{1}{5}$ hp. series motor and set it beside the cash register. The motor was only a shade smaller than the register and weighed even more. "Hmm," he said, pulling at his chin with thumb and forefinger, "this will never do. We'll have to shrink the motor without losing power."

He put Bill Anderson to work on the motor while he began to design the clutch to connect the motor to the register. First he made a clutch of nested coils. It was no good. Next he built a magnetic clutch which picked up power from the motor, whirled the works through one revolution, and tripped a switch to disconnect the circuit. After a number of weeks' work, he scrapped the clutch because he could not make it release its load promptly. He finally developed a little overrunning clutch of the cam and roller type similar to a bicycle clutch. It worked perfectly.

By early April he had the direct current model ready for inspection.

Next he started work on a motor for alternating current.

One morning when he arrived in Inventions 3, he found the work area enclosed by frosted glass panels. "What's the idea of boxing us up?" he asked Bill Chryst. "Who did it?"

"Mr. Patterson. Yesterday he brought a group of visitors through here—I guess you didn't even notice them. He said the place was an untidy mess—too untidy to show visitors. Hence, frosted glass."

"It suits me fine," said Charles. "We won't have to see the visitors. You know, Bill, I've been around here half a year or more and haven't run into Patterson yet. What kind of man is he, anyhow?"

"He's a combination of Julius Caesar and Alice in Wonderland," Bill said. "You'll meet him soon enough."

The Julius Caesar in Patterson was responsible, in a way, for Charles' first meeting with him. By some obscure reasoning process Patterson decided that he could tell the value of a man by how he handled a horse. A man who can't control a horse, Patterson believed, can't control men.

To test his theory, he imported a string of riding horses

and a riding master from England and assigned a horse to each plant executive.

When Charles heard that he was expected to ride a vicious-looking beast named Midnight, he snorted, "My God, it can't be true! Is the man out of his mind?"

"Nobody questions the edicts or sanity of Mr. Patterson," Bill Chryst said. "It's dangerous."

The horses were stabled on Patterson's Rubicon Farm. On his first reluctant visit to the stable, Charles decided that he and Midnight would always remain natural enemies. As he bumped along atop Midnight's back, smoking and swearing at every jolt, he reminded himself of Ichabod Crane.

Mr. Patterson, after allowing a few weeks for the horses and their riders to become attuned to each other, held a review of his troops.

Mounted Caesarlike on his own horse, he held the review with Deeds also on horseback respectfully behind his elbow.

The executives lined up on their mounts and waited at the end of the field. When Patterson signaled by raising his riding crop, each man in turn rode the length of the field, passing before the two reviewers.

Midnight, mean and fractious as usual, gave Charles trouble from the beginning. When he received the signal, Charles kicked the animal in the ribs to make him canter. Midnight evidently resented the treatment.

Right square in front of Mr. Patterson, Midnight planted his feet and stopped dead. Charles, however, kept on going with the result that he landed in a heap at Mr. Patterson's feet.

"Just look at that fellow," he heard Patterson say. "Mr. Deeds, we must get rid of that man!"


Deeds, however, did not fire Charles. He had observed, he

told Charles later, that the president's memory was not perfect by any means.

The work on the motor was not yet finished in July, 1905, when Charles finally decided that he could afford to marry.

He rented an apartment on Lexington Avenue, bought a new suit, and ordered railroad tickets for Niagara Falls via Detroit. When the plant closed down on August 1 for the annual two weeks' vacation, Charles left for Ashland.

5

 It was what the society editor called a quiet wedding on August 1, 1905, in the front parlor of the Williams' home. Immediately after a little wedding supper Ralph Williams, Olive's brother, drove the bride and groom to the station to catch the train.

In Crestline, Ohio, Charles and Olive had a wait between trains. Olive in her new Eton suit sat gingerly on a slatted bench outside the station. Charles paced up and down the platform like some long-legged secretary bird. On one of his tours down the platform he stopped, staring intently across the street.

"Look," he called to Olive, "there's a man over there can't get his automobile started."

Across the street stood a black Oldsmobile before which stood a man wiping his forehead. As Charles started toward him, the man bent down and with two hands on the crank whirled away.

"What's the trouble?" Charles asked.

"Danged if I know," the red-faced driver muttered. "She won't start."

"Let me take a look."

"Know anything about automobiles?" the driver asked, opening up the hood on one side.

"Not much. But I know something about electricity. It could be your ignition, couldn't it?"

"I don't know," the other admitted. "I'm like the fellow

in the joke. Did you hear about the fellow with the new car?"

"Nope." Charles was peering into the engine.

"Fellow said to him, 'How you getting along with your automobile?' Other fellow said, 'Fine.' First fellow said, 'I haven't seen you out driving in it.' Other fellow said, 'Oh, I haven't got that far yet. I'm still learning to make the repairs.' "

Charles joined the driver in a chuckle. "Name's Charles Kettering," he told the man, shaking hands.

The other was the town doctor. "Now you crank while I watch," Charles directed.

Almost at once he spotted the trouble in the ignition system. After a few adjustments with the doctor's screwdriver, Charles directed him to crank again. The engine roared into life.

"Thanks!" The doctor hurried around to the driver's seat to throttle down the gas. "Say, would you like to take a little ride?"

Charles wiped his fingers on a new handkerchief and pulled out his pocket watch. "Half an hour to train time. I certainly would! Do you mind if my—uh—wife comes along?" It was the first time he had used the new word.

"Be glad to have her."

So the bride and groom took their first automobile ride on their wedding day around the streets of Crestline. To the groom it was a high point of the day.

After the doctor returned them to the station, Olive frowned at her new husband. "Just look at those hands, Charlie Kettering! They look as if you have been walking on them."

But her husband was not listening. "Do you suppose we will ever be able to afford an automobile?"

"I don't know," answered the bride a trifle crossly. "Why doesn't the train come?"

The train did come finally and took the honeymooners to Detroit on the first leg of their trip to Niagara Falls.

Knowing Charles, Olive did not expect her honeymoon to be one of listening to sweet nothings and romantic interludes in unlikely places. In this she was not disappointed. Although Charles enjoyed the trip and took a number of photographs to bring home, his mind constantly worked with the problem of shrinking a motor without increasing its tendency to burn out.

At night Olive frequently fell asleep while waiting for him to come to bed. One night she woke quite late to find her husband at the desk writing busily.

"Why don't you come to bed?" she asked sleepily.

"I'm writing to Bill Chryst."

Olive yawned. "Can't you write to him in the daytime?"

"Listen," he said. "I have just suddenly thought of a way to make a motor run on any current." He got up and walked over to the bed. "I can construct the magnetic circuit so that different current conditions can be corrected by slight changes in the field coils. It's as simple as falling off a log. All you have to do is just slip in the proper coil to change from one current to another."

Olive shot Charles a disgusted look and turned over. "Field coils!" she murmured sleepily.

The pattern for their married life was set early. Olive gave up teaching music to manage their home and take care of their money. Charles spent most of his time and energy on the job.

Olive began to see to it that his wardrobe was spruced up. Until she took over the selection of his clothes, he wore his suits too long; his hats were disreputable. With Olive's

help he began to find that his socks and ties matched. She got him into well-tailored suits, but his hats she left alone. The more of a lump his hat was, the better he liked it.

She taught him to dance, much to the disapproval of his Lutheran mother. Frequently she coaxed him away from the shop long enough for dinner at the Algonquin Hotel or an evening at the Victory Theater. But the first time they attended the theater, he sat in the semidarkness covering his program with sketches for the electric cash register. The program later was used in a patent-interference case to prove the date of the conception of the idea.

Because he had no time to read the news and could not have used his eyes to read a newspaper if he had had time, Olive kept up on late events and relayed them to him at mealtime.

Shortly after their coming to Dayton, Woodrow Wilson, President of Princeton University, accused the automobile of bringing socialism to the country. Drivers, he said, are to their countrymen a picture of wealth, causing socialism to spread.

"Best thing that ever happened to the country, the automobile," Charles snorted. "One of these days every family in town will own one."

"Gracious! I can't imagine that. All those men lying on the street under their cars!"

"Reminds me of a joke Mr. Deeds was telling today." Charles chuckled. "Some wealthy doctor built a fancy insane asylum with a special ward for automobile drivers. He was showing the place to a friend. When they came to the automobile ward, the friend said, 'It's a nice room, but I see that you have no one in it.' 'Oh,' said the doctor, 'they're all under the beds fixing the slats.'"

Meanwhile work on the motor for the cash register con-

tinued night and day. When he finally completed his working model, it had a motor about the size of a man's two fists hung on the outside of the frame.

As soon as the machine was in production, the advertising department took space in magazines. "Come and see NCR's newest product—the cash register that runs itself—the greatest innovation in merchandising since the invention of money," the ads said.

Sales were phenomenal. In the first year they were \$1,500,000 higher than in any previous year.

Charles' income went up, too. His salary was raised to \$350 a month. Olive began putting every other pay check in the bank.

But just as soon as storekeepers and tavern owners began to use the new register, complaints began to come in. A man in Chicago was knocked down when he punched a sale. In New York a bartender stepped up to the cash register, rang up a sale, and was pitched across the floor.

The complaints were Charles' problem. He investigated every one, usually by going to see the register owner personally. Often he found that a motor designed for alternating current had been plugged into direct current. Shocks usually resulted when an operator touched the register with wet hands or clothing.

"Why do you let the register be sold when it is so full of imperfections?" a company executive asked.

"The thing to do is get the product into use," he answered. "The customer can show you what is wrong five times faster than you can discover it in the shop."

Although the electric cash register outsold all others in the market, NCR executives realized that the machine was too expensive for many small businessmen to buy. Also, it could not be used in rural areas that had no electricity.

"We need an inexpensive register that will be operated without electrical power and without a crank," Deeds told Charles when he dumped the problem in his lap. "And we need it in a hurry."

Whistling under his breath, Charles pulled out a sheet of drawing paper. In the corner he set down the date—December 14, 1907.

As he worked, he whistled a tune he hadn't heard since he was home on the farm. Bill Chryst, on the other side of the drawing board, listened. "Rock-a-bye, Baby?" he said.

Charles stopped. Taking off his glasses, he polished them carefully with his handkerchief. "Is that what I was whistling?" he finally asked.

Bill nodded.

"I guess I might as well tell you," he confessed. "We—uh—we're going to have a baby."

"Son of a gun!" Bill hopped up and thumped his boss on the back. "When?"

"April."

"Is Olive all right?"

"Fine."

"Who's your doctor?"

"Doctor McCann."

"Good man. Well, Boss, I think that's dandy."

"Thanks. Now what do you think of operating this cash register by a series of springs? Like this." He sketched a register the mechanism of which would be set ready for operation by the force used in pushing the cash drawer shut.

"You'll get some howls from the Demands and Improvements Committee," Bill said. "We tried one like that before. The slamming of the drawer broke the springs."

"Shouldn't," said Charles, "if the steel is good."

He finished the drawings for the register in January and

started at once to build a model. The model was almost finished when the Demands and Improvements Committee paid Inventions 3 a visit. After the executives looked at the drawings and the model, a spokesman cleared his throat.

"Sir," he began pompously, "you simply cannot make a cash register operated by springs."

"Is that so?" Charles' eyebrows quirked in the direction of his model.

"I mean we will not produce such a register," the man amended. "It would not be a satisfactory product."

"Why not?"

"Everybody knows that springs are untrustworthy."

"How so?"

"Why, they stretch."

"So they do," Charles agreed. "They are designed to stretch."

"I mean they stretch and stay that way," the spokesman said huffily. "They lose their tension. They even break. We would have complaints all the time. We can't depend on springs."

Charles put down the screwdriver he had been using. He turned full face to the group, singling out one man he knew was a fancier of antique timepieces. "Would you tell me what time it is, sir?"

The executive pulled an ancient and ornate watch from his pocket. "It is ten twenty-one," he answered.

"Are you sure that is the correct time?" Charles asked.

The man snapped the watch cover shut. "Of course I am!" he barked. "This watch has kept perfect time for fifty years!"

Charles held out his hand. "May I look at it, sir? I would like to see what makes it go."

For a moment the man glowered. Then his shoulders began to shake and he laughed heartily. The others joined

in. "I guess you can forget what we said about your spring-operated register, Mr. Kettering," the spokesman said.

Charles grinned and picked up his screwdriver.

"Well!" exclaimed Bill Chryst when the men had gone, "I guess you really told them."

In three months' time the register was ready for inspection. Deeds promised to bring Mr. Patterson himself to look at the model. While Charles and Bill waited for the impending visitor, Bill kept nervously punching the register.

"For cripes sake, stop fiddling around!" Charles barked. "What's the matter with you, anyhow?"

"Don't you know what Patterson does if a cash register balks for him?"

"Nope."

"Well, once he had some visitors down in the shipping department. He walked up to a cash register and punched a key to show them how it worked. Unfortunately, instead of a machine waiting for shipment he picked one that had been returned for repairs. He punched a key and nothing happened."

"So then what?" Charles asked.

"So then he told the visitors he would show them what the company does with registers that don't work. He picked up a sledge hammer lying on some crates and started swinging. Ten thousand dollars worth of register flew all over that room."

Charles lit a cigar. "The register will work, Bill. If you're nervous, go around and nail down all the axes and sledge hammers in the department."

"He's coming," Bill said huskily. "I see him coming through assembly."

Patterson, followed by a host of executives, bustled into Inventions 3.

"This it?" he asked tersely, marching up to the model. With a forefinger he punched NO SALE. The bell rang; the cash drawer opened. He pushed it shut. He took the cover off and inspected the works minutely. Finally he turned briskly around and fixed Charles with his pale glance.

"Splendid!" he said. "Splendid. Now, sir, how soon can we get into production?"

Charles pursed his lips. "Oh, I'd say roughly in about a year."

"A year!" A frown clouded the plant owner's face. "That is not soon enough, sir. We cannot wait a year. We have competition to meet."

Charles shook his head. "A year for a new model is very good time, sir."

"Now, now," Patterson replied, shaking his finger like a schoolteacher, "it won't do, it won't do. I tell you what, Mr. Kettering. I will double the space you have here and put on twice as many men as you now have working for you. Then you can be ready for production in six months." He turned to leave because the problem had been solved.

"It will still take a year, Mr. Patterson, no matter how you increase the staff."

Patterson whirled, eyeglasses quivering. "Why not?" he snapped. "Any fool knows that if ten men can dig a rod of ditch in an hour, twenty men can dig it in half an hour. Isn't that so, Mr. Kettering?"

Patterson's men and the whole inventions staff stood silent while the little factory owner and the lanky inventor faced each other. "True," drawled Charles, "but if one hen can hatch a setting of eggs in three weeks, can two hens do it in a week and a half?"

For a moment Patterson threatened to erupt. Then a trace of a smile flitted across his face. He turned and marched out of Inventions 3 at the head of his troops.

The Class 1000 register, as it is called, was ready for production in just about a year, a record time for a new product in any factory. Cheaper and better than any product of its competition, the Class 1000 machine is still doing good service in thousands of business places the world over.

During 1908 Charles began work on the Class 2000 machine, a universal register that does everything a cash register does and in addition analyzes sales, purchases, costs, expenses, determines payroll distributions, and controls stocks and production for use in banks, wholesale businesses, factories, and railroad offices.

One problem that gave him a little trouble was how to make the machine subtract.

One day Deeds showed him a drawing of a differential gear for an automobile he was building with the help of a machinist friend. Charles inspected the drawing of the gear that made it possible for the wheels of the automobile to turn at different speeds so the driver could turn corners and round curves.

Next morning, while he was shaving, an idea hit Charles. "Why can't a gear similar to that differential be used to turn counting wheels backward to subtract and forward to add without changing the direction of the drive?" he asked the mirror.

He finished shaving, gulped a breakfast, and hurried to the factory. He and Bill Chryst started to work on the gear at once. By ten o'clock that night the Class 2000 accounting machine had begun to take shape.

Eugene Williams Kettering, the only child of Charles and

Olive, was born on April 20, 1908. The baby looked like his father, who passed out cigars at the plant and took a great amount of good-natured kidding.

The new baby helped fill hours that for Olive were lonely ones, hours when Charles forgot to come home. Poor Olive! Many, many more lonely times were in store for her.

One Sunday afternoon while Gene was napping, Charles walked over to the Deeds' house on Central Avenue. The two men talked shop for a little while, sitting comfortably on an old red leather sofa in Edward's living room.

"I have an idea that keeps buzzing around in my head," Deeds said finally. "I've been thinking that a river of gold is flowing past our door in the automobile business. Why don't you and I put out a dam and direct some of that gold our way?"

"How do you mean?" asked Charles.

"I met a couple of fellows when I was working in the East," Edward said. "They had a little factory. One of them ran the shop and the other took care of the business. It worked out quite well. Now I was thinking that you and I could do something like that—you could run the plant, I could handle the business. We could make something for automobiles."

Charles pushed out his lower lip. He looked at Edward over the top of his glasses. "Well, if we are going to make something for automobiles," he drawled, "I can tell you mighty fast where we ought to start."

"Where's that?"

"With the ignition system. It's a nightmare how fast the ignition goes haywire, and a fellow ought to have an electrical engineering degree and a carload of tools to fix it."

"You're right, Ket. I know I wouldn't be able to get my

Suburban Sixty to Miamisburg and back if I hadn't studied electrical engineering in school myself."

"A person ought to be able to come up with something foolproof," Charles said.

"What do you say we give it a whirl in our spare time?" Deeds asked. "We could work in my barn. There's a whole loftful of tools out there left from when I built my car."

Charles' eyes began to sparkle. "Gee, it would be wonderful! But I don't have any money to put into it, Mr. Deeds."

"I have, and I'm more than willing if you are," was Edward's answer. "What do you say let's go out and look the tools over?"

The two-story barn on the back of the lot had been built for horses and carriages. But now the Suburban Sixty stood where Dobbin had had his stall, and hay in the loft had been cleaned out for a shop. The two men hurried up the twisting, narrow stairs. When he saw the equipment, Charles let out a low whistle.

"I think there's plenty of stuff here," Edward said, throwing open a few shutters that covered dusty windows. "Milling machine, engine lathe, drill press, tool grinder, oscillograph, ten horsepower motor. Think of anything else you need?"

"I'll bring my own screwdriver," Charles told him, grinning.

Ignition in the 1908 automobile was a nightmare to drivers. Neither of the two systems in use worked satisfactorily. The magneto was so weak that it caused the engine to buck and die when driven in high gear at low speeds, as in city driving. The auxiliary vibrating coil dry cell battery system, which was used in conjunction with the magneto,

failed to provide enough current to operate at high speeds. The dry cells produced a shower of weak sparks outside the cylinder that quickly exhausted the battery charge. The set of batteries had to be replaced about every 200 miles.

The idea Charles had in mind was to develop a system that would eliminate both flaws. He and Edward began working in the hot hayloft during the summer of 1908. Since both men were working at NCR during the day, they could devote only nights, Sundays, and holidays to the project.

Every afternoon when they arrived at the barn, they hurried to the loft. Usually Charles worked at the bench for a time, explaining to Edward what he was doing. Then he picked up a screwdriver, dashed down the stairs, lifted the hood of the Suburban Sixty, and poked his head under it. While Edward held a light, Charles fitted in a part and tightened it.

"Now let's try her." He slammed down the hood and ran around to the front of the car to crank the engine while Edward jumped into the driver's seat to adjust the choke and gas.

With the engine running, Charles hopped into the car beside Edward and the two went roaring up the alley. Around the block they tore, listening to the engine, accelerating, braking, stalling. Soon back they came, leaping out for more tinkering.

The Barn Gang, as they began calling themselves, was joined by Bill Chryst and later by other men from Inventions 3.

Night after night the men toiled away in the hayloft. Sometimes Edith Deeds or Olive brought sandwiches. Frequently the men skipped meals completely.

Charles finally decided to do away with the magneto system entirely. He planned to build a battery system with a

controlling relay rather than vibrating coils. The result, he figured, would be a single, fat spark inside the cylinder instead of a shower of weak ones outside. He reasoned that the fat spark would give better combustion, with no stalling and better engine performance. Since he needed an automobile of his own, a commercially manufactured one, on which to experiment, Olive's savings went for a Cadillac roadster.

The year 1908 slipped into history. The Republicans nominated William Howard Taft for President; the Democrats again put up William Jennings Bryan. Orville Wright came home from Fort Myer, Virginia, where his plane had crashed, severely injuring him and killing his passenger, Lieutenant Selfridge. Wilbur, flying in France, broke two world's records. With a passenger he stayed in the air 55 minutes, 37 seconds. On another flight he flew higher and farther and longer than a plane had ever been flown before—360 feet high, 120 kilometers distant, and 113 minutes aloft.

Postmaster General Meyer said that if nobody cared when or where the mail was delivered, airplanes might conceivably one day be used in his department.

Henry Ford brought out a six-cylinder car that sold for \$2800.

When the city council of Cincinnati decided that automobile drivers should be licensed, the mayor told the council to ignore women because "they are physically unfit to operate a car."

Women began wearing the sheath gown in 1908. Dresses still touched the floor, but the hips and petticoats disappeared. Men told their wives that they looked like seals reared on end, that the sheath uncovered a multitude of shins, and that it was a step backward toward the fig leaf,

but the women paid no heed. They wore their sheaths and Merry Widow hats and started smoking in public.

Charles paid little attention to what was going on in the world outside the barn. Early in 1909 he and Deeds decided that if ever the ignition project were to be completed, Charles would have to give up his job at NCR to spend his days as well as nights in the barn workshop. Although Deeds promised to make it financially possible for Charles to give up his NCR job, both Charles and Olive had grave doubts about the wisdom of giving up a steady pay check.

But after much thought and discussion he resigned as head of Inventions 3 at NCR. He had been with the company for five years. In that time the four major products he developed—the electric cash register, the OK Charge Phone, the spring-operated Class 1000 machine, and the beginning of the Class 2000 accounting machine—had become the major source of income for the company.

Now he began working day and night in the barn. Sometimes he got home for lunch, sometimes for dinner, and sometimes not at all.

Late in the summer of 1909, he told Edward he believed that the ignition system was ready for testing.

“Why don’t you and Mrs. Deeds take my auto for a trial trip?” he suggested. “I’d like you to see how it works. I’ll take a day or two while you’re gone to take Olive and the boy to visit our folks. They’ve never seen the baby.”

A few days later Edward and his wife set off for New York in the roadster. The Ketterings headed for Ashland and Loudonville on the train. Charles’ father and mother and David kept the farm alone now. Adam, Emma and Daisy had all married and left home, although all of them lived closed by.

Seeing the old home place with a fresh viewpoint since

he had been away so long, Charles began to worry about his parents.

"You have to work too hard," he told them. "There ought to be someway to have electricity on the farm. Dad could have an electric pump and cream separator and mother, you could have an electric iron like Olive's and lights to read by and a washing machine and a vacuum cleaner."

Martha Kettering laughed, the wrinkles around her eyes deepening. "If we all had those things, son, we wouldn't know what to do with our time. Besides, they all cost money."

"If I ever get rich, Mother," Charles promised, "I'll fix the house up with all those things and water and a furnace, too."

"Oh, Charlie," Martha laughed, "how you talk! Imagine a Kettering ever getting rich!"

"Just the same," said Charles, "I've made you a promise."

When Charles and Olive and the baby arrived back in Dayton, the Deedses had already returned from their trip. The telephone was ringing in the apartment when they unlocked the door. Edward said he wanted to come right over. He burst into their living room a few moments later, full of news.

"What a trip!" he shouted, his blue eyes dancing. "Ket, you'll never believe it! We made that twelve-hundred-mile trip on one set of batteries, and there's life in them yet!"

A grin spread over Charles' long face. "How about the stalling?"

"Not one time. Not one single, solitary time!"

"Wow!"

The two men started pounding each other on the back and shouting like schoolboys. Olive dashed into the room, fingers to lips.

"Sssh!" she cried. "Hush, you two Indians. You'll wake Gene up."

"All right." They lowered their voices. "It really worked all right, did it?" Charles asked again, just to be sure.


"Perfect. Couldn't be better."

"Oh, I wouldn't say that," Charles drawled. "But there's one thing that does bother me."

"What's that?" asked Edward.

"Now that we have this new ignition, what are we going to do with it?"

6

 "What are we going to do with it?" Edward echoed. "Sell it, I hope. I've already written somebody about it."

"Who?"

"Henry Leland."

Henry Leland, white-haired, white-bearded general manager of the Cadillac Motor Car Company, had long devoted himself, both Edward and Charles knew, to producing a quality automobile rather than trying for volume sales.

When Leland became manager of Cadillac, American automobiles were termed "glorified baby carriages" by European manufacturers because they were assembled cars rather than manufactured in one plant. Bodies came from carriage makers, and spark plugs were handmade. As a result, replacement parts might fit or might not. Usually they had to be filed or hammered into place by a blacksmith.

Leland did away with the assembled car. He brought the complete manufacturing process under one roof and demanded that all parts for the Cadillac be identical so that any part would fit any Cadillac.

In 1908 he demonstrated to the world how excellent his technique was.

Three Cadillacs were driven from the London, England, showroom to a demonstration point and disassembled. Eighty-nine parts were removed from the automobiles and

locked away under guard. New replacement parts were added to the heap in which all the other parts were jumbled.

Each car was rebuilt from the heap, screwdrivers and wrenches being the only tools used.

Once assembled, the cars were driven 500 miles around a race track. Each automobile set a new speed record.

Because of the demonstration, the Royal Automobile Club of London presented Cadillac with the Sir Thomas Dewar Cup, the most highly prized award in the automobile industry. The victory showed the superiority of precision production over hand methods of building a product and paved the way for American mass-production methods.

"Think Leland will be interested?" Charles asked.

"I can't imagine why not. Whoever comes out with this ignition will make automobile history."

"History doesn't interest me." Charles laughed. "It's the future I am thinking about."

Very shortly they learned that Leland was indeed interested in the ignition. He sent his chief engineer, E. A. Sweet, from Detroit to look it over.

The two men picked up Sweet at Union Station in Charles' Cadillac roadster. They gave the automobile a good day-long workout, driving through the hilly area south of town over unpaved city streets, gravel roads, chuck holes, and mud puddles. All day long the ignition performed perfectly. Not once did the engine buck or stall.

When Sweet had to take the night train back to Detroit, they drove him to the station and waited with him.

"I like your ignition very much," Sweet told them as the train pulled in. "I am going to recommend it to Mr. Leland."

Charles beamed at Edward. As soon as the train pulled out, they pounded each other on the back and hurried back to the roadster. Edward got in to adjust the gas, Charles

loped around in front to crank the engine. He grasped the crank in both hands and whirled it. Nothing happened. He gave the crank a second whirl. Nothing again. Straightening, he stared unbelievably along the hood into Edward's blue eyes. Dropping the crank, he hurried around to the side of the engine and lifted the hood.

Edward joined him. "What's wrong?"

Charles held up a loose wire. "It must have snapped when the engine cooled off while we were in the station, or it could have jolted loose on those hills today."

"Thanks be to God it didn't happen while Sweet was with us," Edward said fervently.

Charles brought the tool kit from the running board, rolled up his sleeves, loosened his tie, and went to work. In a little while they tried the engine again. This time it caught and coughed into life. Charles piled into the car beside Edward, and they headed for Dayton View Bridge.

Three days later they received a letter from Leland asking them to express an ignition for testing. They packed it into a wooden box as carefully as if it were an orchid. Shortly afterward they received another letter asking the two of them to come to Detroit for a conference.

It was two lighthearted, hopeful men who packed their bags for the trip. Edith decided to go along. Olive had to stay at home to look after Gene.

Plans were for Charles to visit an old friend overnight. The Deedses were to stay at the home of Arthur Fisher, where Edith remained while the men went to Leland's office for their conference.

The conference lasted for four hours, while the fatherly Leland bombarded the two young men from Dayton with questions. At last he thumped the desk.

"Young men," he said, "I have decided to take a gamble on your ability and integrity. I will put your ignition on the 1910 Cadillac." He picked up a paper. "I have already drawn up a contract," he continued. He handed it to Edward, who read it and passed it on to Charles. He saw 8000 ignition sets and returned the paper to Leland.

"Now I'll just fill in the rest," Leland said, picking up a pen. "What is the name of your company?"

The two looked blankly at each other. "We don't have a name," Edward confessed.

"No matter. Suppose I make this out in your name, Mr. Deeds."

"Fine with me," Charles said.

Leland filled out the contract, gave it to Edward to sign, signed it himself, and handed a copy to Charles. The three stood up and shook hands all around. Then Edward and Charles found themselves in the hall.

"I'm stunned," said Edward.

"We're in business," Charles said, "but we don't really have a business."

"We have an order for eight thousand ignition sets, but no factory," Edward pointed out.

"And no name for it."

"And no capital. A name is no problem, but we need money to build a factory." Edward mopped his forehead with his handkerchief.

"Hah, what's money?" Charles asked. "You realize that those 1910 Cadillacs have to be in the hands of the dealers in just a few months? What we really don't have is time! Come on, we've got to get back to Dayton and go to work!"

In a borrowed car they drove away from the plant.

Charles decided to stop off for a shortened visit with

his college friend while Edward drove out to pick up Edith. As Charles stepped from the car, he noticed the contract sticking out of his pocket. Pulling it out, he tossed it on the seat.

"You take this darned thing. I don't want it," he said.

Back in Dayton, Charles telephoned Bill Chryst to meet him and Edward at the barn. As soon as he arrived, the three planted themselves around a desk and began to talk.

"We will have to incorporate," Edward said.

"You'll have to have a name to do that," Bill pointed out.

"I have been thinking about a name ever since we left Detroit," Edward said. "What do you think of 'The Dayton Laboratories and Engineering Company'?"

Charles looked at Bill. "Seems to me it's a little awkward," Bill said. "How about turning it around? 'The Dayton Engineering Laboratories Company'?"

"Naah," said Charles. "I don't like it."

"Can you think of anything better?" Edward asked.

"Nope. Let's use it."

So the Dayton Engineering Laboratories Company, soon shortened to Delco, was incorporated on July 21, 1909, with a capital stock of \$150,000, two-thirds of which was in common stock. Charles and Edward each owned half the stock and together became joint owners of all contracts and patents. Edward became president, Charles vice president. They opened an office in the United Brethren Publishing House building at Fourth and Main.

"Now then," said Edward when the final papers had been drawn up, "has anybody any idea as to how we can get eight thousand ignition sets built in about three months? Are we going to start a factory to make them?"

"I don't want to be loaded down with manufacturing

problems," Charles said flatly. "I'm just interested in hatching out ideas. Let somebody else do the manufacturing."

"Who?" Edward asked. "Is there anybody in town who can turn out the sets as fast as we need them?"

Charles ran his hand through his thinning hair. "Not that I know of. When I was working for the Star Telephone, I met a fellow from Chicago named Edwards. He was with a company, the Kellogg Switchboard and Supply, that makes stuff for telephone companies. I should think he could make ignition sets."

"Why don't you call him?" Edward suggested.

He called Edwards who said he could and would make the sets if Charles would come to Chicago and show him how. He put down the receiver, made a dash for the apartment, changed his shirt, threw a pair of pajamas and a clean collar into a bag, stuffed an ignition set in the top of it, kissed Olive and Gene, and rushed down to the railroad station.

Edwards agreed to start shipping sets to Detroit within two weeks. Charles stayed around the factory a few days and then left for home. On the train back he picked up a newspaper and saw a large Cadillac advertisement announcing the new Delco ignition. "Nothing on the dash but the switch," the ad said. Charles put the paper on the seat opposite him, crossed his feet on it, and went to sleep.

Back at home Charles soon received word that Kellogg had begun shipping sets to Detroit.

"It looks as if our problems are solved," said Edward when Charles told him.

"Never think that," Charles replied. "When you believe that, the concrete is starting to set in your head."

Charles was right. He was finishing supper a few evenings later when Earl Wellborn, the Delco office clerk, telephoned.

"There's a telegram here for you, Boss," he said. "Should I read it to you?"

"Go ahead. Where from?"

"Detroit. It says SORRY TO INFORM YOU CONTROLLING RELAYS STICKING STOP LELAND."

Charles slammed down the receiver.

"Pack me a bag, Olive," he said, "I've got to go to Detroit. No, you look up the timetable and tell me when the next train leaves. I'll pack the bag."

"Oh, dear," sighed Olive. "How long will you be gone?"

"Don't know," he shouted over his shoulder as he disappeared into the bedroom.

He caught the evening train to Detroit. When he walked into Leland's office early the next morning, he found Leland and six other top Cadillac executives sitting glumly around a conference table.

After introducing the men, Leland motioned Charles to a chair.

"We are very much disturbed, Mr. Kettering," Leland began. "None of the ignition sets we have been receiving will work. We have tested each new shipment every day as it comes in. Not one works." He looked searchingly at Charles over the top of his rimless glasses. "Now our new models have to be shipped to the dealers, not in a matter of months, sir, not in weeks, but in days. If you cannot find the trouble at once, we simply will have to bring out the new model without it."

Charles swallowed hard. He and Deeds had promised to pay the Kellogg Company for making the sets with the money Leland would pay them.

"I have no doubt that a minor adjustment is all that needs to be made. Will you have someone show me the way to your factory?"

"Certainly."

Charles got to his feet, nodded to the executives, and walked out into the hall. Leland followed him.

"I like the way you go at the problem, young man," Leland said. "Most men in your shoes would have called Kellogg first instead of coming here or at least would have started going over the blueprints."

"I am the screwdriver and pliers type, Mr. Leland. I do my work at the bench. I can't do that by long-distance telephone to Chicago."

Leland gave Charles a bench, some hand tools, and a stack of ignition sets still in cartons. Then he left him alone.

Charles hung his jacket on a nail, loosened his tie, and started confidently to work. After all, he knew the ignition set from the ground up. Probably some little wire was twisted the wrong way.

"I'll find it in no time," he told himself.

He began by checking the batteries and connections. Then he went over the armatures and relays. Everything seemed to be in order. Whistling softly to himself, he checked the set once more. Then he connected the set to the test engine and cranked it. Nothing happened.

Lunchtime came and went, but Charles stayed at the bench. He tore the set completely to pieces and rebuilt it, inspecting each part as closely as his weak eyes would let him. When he connected the rebuilt set to the engine, it still wouldn't start. He tore down another set and rebuilt it with the same results. He scratched his head. What to do? Maybe he had missed something.

He tried another set.

A long time later when the quiet around him made him look up, he discovered the factory was empty. Outside the windows darkness had gathered.

Charles looked at his watch. The night train left for Dayton in half an hour. He certainly wasn't getting anywhere here. Maybe someone in the barn gang could find the trouble.

He threw an ignition set into his bag on top of his clean shirt. He buttoned his collar, tightened his tie, put on his coat, and left the factory.

In his berth on the train he lay with eyes staring up into the dark. What could be wrong? As the train rocked along on the uneven tracks, he retraced in his mind every wire, every bolt, every part of the ignition. Where was the flaw? The hours crawled by but brought no answer to the question.

He punched his pillow, turned on his stomach, and tried vainly to go to sleep. Finally he reached for his bag and pulled it to him in the darkness. Taking out a set, he held it on his stomach, letting his skilled, sensitive fingers wander over the set. Yes, the wires were connected properly. He ran his forefinger over a pole piece. What's this? He sat straight up in his berth. Quickly his fingers located the other pole piece. They had looked perfect to his nearsighted eyes, but his fingers told him a different story. The pole pieces were supposed to be machined perfectly flat, but these felt rounded. At once the thought occurred to him that because of the rounding, the magnetism would be concentrated, holding the armature closely to the pole piece. Since it could not be released when needed, the relays would stick. He put the set back into his bag, turned over, and went to sleep. As soon as the train arrived in Dayton, he bought another ticket for Detroit. Then he took a cab out to the barn, raced up to the loft, machined the poles flat, hooked the ignition set to his roadster, and cranked. The engine turned over smoothly.

Unhooking the set, he jammed it into his bag and hurried back to the station. He stopped to wire Leland and then jumped onto the train.

Back in Detroit he showed Leland what had caused the trouble. Then he dashed for a Chicago train to straighten out the trouble at the Kellogg plant. Two days later he walked wearily into his own living room, and dropped his bag on the floor. Olive hurried in from the kitchen and kissed him.

"Have you just come from the office?" she asked.

"No. Chicago."

"Then you don't know about the telegram?"

He dropped heavily into his favorite chair. "What telegram?"

"I think somebody wants you to go to Detroit."

He groaned. He dragged over to the telephone and called Wellborn.

"Well," he said, putting down the phone a moment later, "I guess you'd better put a clean shirt in my bag. Something has gone wrong with the ignition sets again."

"You have to go back again? Right away? Can't you even stay for supper?"

"Nope. I'll miss the train if I do." By this time he had memorized the train schedule.

"What's wrong?"

"Engine misfires. Stalls sometimes."

"Can you fix it?"

"Have to. Every cent we have is tied up in this ignition business. I've even borrowed on my insurance."

"Oh, Charlie!" Olive's tone reproached him all the way to the train station.

The porter on the train remembered him. "You back again, sir?" he asked.

"If anybody asks," Charles told him, "my address is Car 236, Upper 4."

By now the way to Leland's office was familiar to Charles. "What's the trouble this time, sir?" he asked as soon as he planted a foot inside the office.

"The ignition starts the engine fine, even a cold one," Leland said. "But when you start to drive in high and give her the gas, she bucks. Sometimes the engine dies completely. Then you get out and start her again and snort along for a while and then all of a sudden she takes off like a scared jack rabbit. Runs fine from then on."

"Hmmm," said Charles. "Let me take a look."

Once again he spent the day in the factory, trying every way he knew to find the trouble.

"The only thing I can figure," he told Leland, who came out where he was sweating and getting dirtier by the minute, "is that it's the coils. I can't find a thing wrong with them, but that's the only thing it can be."

"I must remind you, Mr. Kettering," Leland pointed out, "that we are about to ship demonstration cars to the dealers. I can't wait a week for you to get new coils. We must have them by the day after tomorrow at the latest or go back to magneto ignition."

Charles gulped. He picked up an ignition set. "I'll be back with this in plenty of time, Mr. Leland," he said. But on the train he began to have doubts. He had wound those coils himself. They were the best available. When he had checked them in the oscillograph in the barn they had produced perfect sparks. Now where could he get better ones by tomorrow?

He tried running his fingers over the ignition in the dark, but this time they worked no magic. He turned and rolled all night long in the stuffy upper berth. For himself he

didn't mind if he failed. He could try again. But there were Olive and Gene depending on him and Edward Deeds and the fellows in the barn gang and Henry Leland.

He swung off the train in the early morning, tired, dirty and worried. Hurrying to the barn, he wired the coils to dry-cell batteries, using an adjustable spark gap instead of spark plugs. Then he began to test. He knew that failure of the spark to jump caused the bucking and stalling, but his coils gave a fat spark every time. He tried other coils but always came back to the ones that had given the trouble in Detroit. What to do? The last train left shortly before midnight and he had to be on it or the whole business would collapse. He tested all morning, all afternoon, and all the early evening without success.

He sat in the gathering dark, fiddling dejectedly with his screwdriver. He had set the spark adjustment rather close, as close as it was in the automobile. Now he turned the screw, unconsciously widening the gap. The spark failed. In the darkness Charles could see the blue corona around the terminal. With a reverse twist of the screwdriver, the spark jumped again.

He began to shake with fatigue and excitement. The corona prevented the spark from jumping. Now to get rid of the corona. Every adjustment that could possibly be made he had already made, except one. Suppose he switched the wires leading from the dry cells to the terminals? Of course, everybody knew that the positive wires should go to the spark plugs. Still, everybody could be wrong. Quickly he switched the wires so that the negative ones led to the spark plugs and the positive wires to the terminal. He turned on the current. No corona! For ten minutes he watched the fat spark hopping tirelessly, a smile beginning to form at the corners of his mouth.

Next morning at the Cadillac plant, Leland asked Charles whether he had been able to build new coils.

"Didn't need to," Charles told him. "The ones we have are the best there are."

"We can't use your ignition, then," Leland said. "I'm sorry, Mr. Kettering."

"Oh, I wouldn't say that," Charles said. "Got a cold motor around here?"

They walked over to a car standing in the factory yard.

"All we have to do," Charles explained, "is switch these wires." With his fingers and a screwdriver he made the change. "When the engine gets cold and the metal contracts, the spark gap widens. It's hard for the spark to jump across the wider gap. The corona effect makes it misfire. Of course when the engine warms up, the trouble disappears."

"But everybody knows that the positive wires should go to the spark plugs," Leland objected.

"Is that so?" Charles grinned. "Now try it."

The engine started beautifully and when Leland put it in high gear and stepped on the gas, it roared along smoothly as even he could desire.

"You know, Mr. Kettering," he said as Charles was about to leave for home again, "when I send for most men by telegram, they sit down and write me a letter. But you hop on the train and come. I like that."

Charles grinned.

No more telegrams came from Leland. Very shortly in 1910 Cadillac appeared with the new Delco ignition. Buyers of the new model were delighted with the smooth performance. Leland received congratulations by the hundreds. When he paid for the ignition sets, Edward and Charles paid Kellogg and settled up their other debts.

And then the trouble came again. A man in Syracuse,

New York, named C. Perlee Noxon had invented a controlling relay to use on a motorboat and had received a patent for it.

"I'll go see him," Edward said. "This is in my end of the business."

He went to talk to Noxon and bought his patent. He was forced also to buy a similar patent from an inventor in Paris. But that ended that kind of trouble.

One morning when Charles was shaving on the train coming home from Chicago, he heard two men talking about the Cadillac ignition.

"I guess they're going to leave the magneto off entirely next year," one man said.


"My cousin owns a magneto company," the other remarked. "And this new dry-cell battery is losing him business hand over fist. But he's not licked, he says. He and the other magneto people are going to come up with something."

"What sort of thing?" asked the first man.

"I don't know. He didn't say. But knowing him, I'm pretty sure it will be something good. Old Uncle Henry will be putting the magneto back in his Cadillac, I've no doubt."

Charles finished shaving and went back to his seat. So the magneto people were planning something, were they?

7

 News that heavyweight boxer Jack Johnson had defeated James Jeffries in Reno, Nevada, for the heavyweight championship of the world on July 4, 1910, was the most exciting item Olive reported to Charles since Halley's Comet had passed near the earth in May. Olive had just finished reading the round-by-round description of the fight to him over breakfast when the doorbell rang.

Olive opened the door; a uniformed boy handed her a yellow envelope.

"Telegram for you, Charlie," she said, handing it to him. "I suppose I might as well start packing your bag for Detroit."

He slit the envelope flap with his knife. "Yep," he said, "It's from Leland."

"If only you could stay home once in a while, dear!" Olive lamented. "I think Gene doesn't even recognize you when you come back from your trips."

"This time I'll wear a sign," Charles said drily.

"Is it something wrong with the ignition again?"

"Don't know," he answered. "It might be trouble with the magneto boys. I've been expecting that."

"When will you be back?"

"Don't know that, either. When you see me."

The late train from Dayton put Charles in Detroit just about the time Henry Leland got to his office. The next morning when Charles appeared in the office, he found

Leland sitting with his head between his hands. When he saw Charles, he brightened somewhat, jumping up to shake hands.

"Sit down. Sit down, son," he invited. "I'm so glad you came so promptly. Mr. Kettering, did you ever hear of an automobile called the Carter Car?"

"Think so," said Charles. "It is made here in Detroit, isn't it?"

"Yes. The head of the company is a very close friend of mine, Byron T. Carter. Or rather, he was a close friend. I went to his funeral day before yesterday."

"Oh?"

"It was my fault that he died. A month or so ago Byron was driving home across the Belle Isle bridge when he saw a woman standing beside a stalled Cadillac right in the middle of the bridge. Traffic was jamming up behind her. Well, Byron got out and offered to crank the engine for her. He forgot to check whether the spark was retarded. It wasn't. The crank flew up and smashed his jaw. He died this week of complications."

"That's too bad." Charles knew of similar accidents. Every driver did.

"Mr. Kettering," Leland went on, his fingers fretting with papers on his desk, "at least six men in my factory are laid up with broken arms right now, all caused by jumping cranks. I absolutely must do something about it! I am breaking arms of people all over the country."

Charles rubbed a thumb along his lean jaw. "Mr. Leland, it seems to me that an engine might be cranked by electricity."

Leland's eyes brightened. "Do you really think it is possible?"

"I do."

Leland jumped to his feet. "Mr. Kettering, if you can design a satisfactory self-starter, I will put it on the 1912 Cadillac!"

Charles unfolded his long legs and got up, towering over Leland. "Then I guess I'd better go right home and get to work," he drawled.

"Fine," said Leland. "We ought to have a test model by early fall."

"I'll try."

"Good. I'll put one of the new engines on the train with you."

All the way home, Charles turned the idea over in his mind. Other men had tried to invent a self-starter, he knew. Most were mechanical starters, using springs for power, but none had been successful.

Early next morning he got Edward to help him carry the engine into the hayloft.

"What's this for?" Edward asked, easing the engine onto a block.

Charles was mopping his forehead. "Bet it's a hundred and thirty-five in here," he puffed. "Let's get some air." He threw up a window. Then he told Edward about Leland's offer. "Today I'm going to rig up some kind of self-starter. If it can turn the engine over, I will know that it can be done."

Essentially the self-starter presented the same problem as the electric cash register—the need for a motor with high torque to give an initial strong burst of power.

Charles set out to visit an implement dealer's shop and returned loaded down with chains, pulleys, and sprockets. Hooking up several storage batteries and a makeshift electric motor, he worked all day rigging up an elaborate piece of mechanism. Other members of the barn gang helped.

By late afternoon he had the collection of hardware hooked up to the starting mechanism of the motor.

"Think it will work?" Edward asked, watching him fasten the last wire in place.

"We'll soon see."

Others of the gang gathered to watch and held their breaths as Charles flicked the starting switch.

The contraption clanked and turned as the batteries poured life into the sprockets and pulleys. The test engine gave a spasmodic gasp and began to revolve. The engine caught and roared. As Charles cut out the starting motor, the engine settled down to an idle. Then he stopped the engine by putting four fingers on the spark plugs.

"It worked!" The gang pounded one another on the back. "He did it!"

"I think it can be done," Charles observed cautiously. "The real work starts now."

Since the makeshift starter Charles had improvised was larger than the automobile engine itself, he knew he had to shrink the motor until it was small enough to fit into a chassis, yet powerful enough to start the engine.

Charles was not the first man to try to invent an electric self-starter. Others had developed the idea of starting the engine by battery and recharging the battery with a generator driven by the engine. Patents had been issued for the principle. But what had stopped the other inventors was that a generator increases its output of electricity in proportion as the speed of the automobile increases. No one had ever figured out how to keep the generator speed constant.

Charles believed that he could keep the generator from discharging too much electricity and ruining the battery by using a series coil to produce 24 volts for starting the engine

and a shunt coil to feed 6 volts from the generator into the battery.

Years before he had read in an electrical magazine that in order to furnish constant current for electric lights on trains, a series coil was wired in reverse against the shunt coil with the result that the faster the engine drove the generator the more the series coil worked against the shunt. Other inventors had doubtless read the article, too, but Charles remembered it and used the principle successfully.

He put Bill Mooney, one of the new staff members, to winding coils while he worked out the intricate switch required for the field coils. At the same time he designed an overrunning clutch to let the engine run ahead after the starter had turned it over, using a clutch similar to the one he had made for the electric cash register.

By November, Leland was asking frequently to see a test model. What was holding up the work was the difficulty Charles had in finding a suitable battery. He needed a more powerful battery than any in existence, yet it had to be extremely small. He had sent out letters of inquiry to almost every battery manufacturer in the United States. As yet he had few replies, every one unfavorable.

One morning he had just finished reading another letter from Leland and was sitting dejectedly on his spine with his legs stretched out in front of him, a worn checked golf cap pulled down over his eyes.

"Is this the Delco office?" a voice asked.

Charles shot a glance from under his cap toward the open door. A tall, wiry young man carrying a brief case stood in the doorway.

"It is," drawled Charles. "Anything we can do for you?" He pushed his cap back on his balding forehead.

"I am looking for a chap named Kettering."

"What for?"

"My name is O. Lee Harrison," said the stranger. "I represent the Electric Storage Battery Company of Philadelphia. We received a letter from this Kettering. He thinks he needs five thousand storage batteries."

Charles recovered his feet and jumped up. "I'm Charles Kettering," he said, extending his hand. "Come in and sit down. So you think you can sell me the batteries?"

"Actually, no," Harrison told him. "I didn't come here to sell you anything. I was simply curious to see what kind of a fellow thinks he needs five thousand batteries."

"You're looking at him," Charles said. "If you have the time, I would like to show you why I want them. Will you come out to the barn with me?"

"Barn?" Harrison chuckled. "I haven't been in a barn since I left the farm. I guess I have the time."

"Good. Grew up on a farm, did you? So did I."

The two men chatted farm talk while he drove them to the barn. Five or six men were at work on the various parts of the starter. Charles introduced them all. He showed Harrison the starter and described the kind of battery he needed to make it work.

"I guess you know there just isn't any such battery, don't you?" Harrison asked.

"Yes. But you can make one, can't you?"

"I suppose so. It will have to be a special job. Can you pay for the batteries?"

"Right now I haven't a cent," Charles told him.

"How's your credit?"

"No credit. But when Leland pays for the first order of starters, then I can pay you."

"My boss will say you're not a good risk," Harrison said.

"But I'm going to take a chance. I believe you know what you're talking about. I'll see if I can get you your battery, Mr. Kettering."

Charles grinned.

He waited impatiently for a couple of weeks to hear from Harrison. Finally one morning Earl Wellborn had a call from the railway station.

"There's a shipment for you down at the depot," he told Charles. "From Philadelphia."

"The battery!" Charles shouted and bolted out of the office. The minute he saw the crate on the platform, he knew he could not use it, but he took it to the barn, uncrated it, and put it on the scales. "Sixty-five pounds," he muttered. "My gosh!"

BATTERY TOO HEAVY AND TOO BIG STOP TRY AGAIN, he wired Harrison.

Within a week another battery, considerably chiseled down, arrived.

"Looks small enough," Charles said when he unpacked it. "But will it do the work?"

The date was December 17 and dealers were howling for the new model. If the battery worked, the barn gang boys might have a good Christmas. They gathered around while he assembled the starter and attached it to the shiny new test engine on the block.

"Well, boys," he announced, taking a deep breath, "this is it!"

He turned the switch. Nothing happened. The men stood silently around the engine.

Charles tried it again.

Nothing.

"I guess we'll have to check," Charles said.

For seven days they went over the clutch, the coils, the

generator, the battery. Nothing helped. But on the day before Christmas Charles found a faulty armature. He rewound it as quickly as he could and put it back in place.

"We'll try it again," he said.

Again the men gathered around the engine. Again they held their breaths. Charles turned the switch. The sweetest sound any of them had ever heard filled the barn loft.

"Yippee!" yelled Bob DeMaree. "Wow!"

"And a Merry Christmas to all of you," added Charles.

He sent off the good news to Leland before he went home for Christmas Eve with Olive and Gene.

Three days after Christmas a 1912 Cadillac arrived at the railroad station, by express. Charles cranked the engine and drove it out to the barn. Bill Anderson brought the starter down from the loft.

He stopped the engine, climbed out of the car, and walked around to the front. He lifted the hood. "Oh, my good gosh!" he shouted.


"What's wrong?" Bill set the starter down on the running board.

Sputtering, Charles pointed to the engine. "The dad-blasted idiots didn't leave room for the starter!"

Bill stared. Others of the gang gathered around. Bob DeMaree whistled. "What are we going to do?"

He slammed down the hood and headed for the loft, followed by the gang. "I believe it is advisable to reduce the size of the starter," he said glumly.

8

 Reducing the starter size meant new drawings, new tools, new castings, new armatures, new everything. The barn began to boil.

Leland, anxious because of the delay, wrote that if Charles could not produce a test automobile shortly, he planned to consider another kind of self-starter that had been submitted.

Charles threw the letter away and began pressing everyone to work harder.

February 10 Charles received a telegram.

AM LEAVING IN ONE WEEK FOR BERMUDA STOP
IF SELF-STARTER NOT READY FOR TESTING
BEFORE THEN MUST ABANDON PROJECT STOP
LELAND.

Charles tossed the telegram on his desk. "There is more than one week's work to be done."

Bill Anderson nodded. "There's two week's work, but we can get it done in a week if we work twenty-four hours a day."

"But nobody can stay awake night and day for a week," said Charles.

"I think it can be done," said Bill. "When I was working for a steamship company, I sometimes did tricks of a hundred hours on a cup of coffee with a teaspoon of rum in it every hour. It makes a man able to stay awake almost indefinitely."

Charles laid in a supply of coffee and rum. For the next five days the gang worked around the clock. On the fifth day Bob DeMaree crawled under the automobile to spell a man who was almost asleep with his eyes open. Bob called to Bill Anderson, "Hand me a pair of pliers, will you?" Before Bill could hand them to him, Bob fell sound asleep.

In the early hours of the sixth day Charles connected the last wire of the new small starter. Everybody gathered around while Charles climbed into the driver's seat. He pressed the starter button and let out the clutch. Nothing happened.

He sagged forward on the steering wheel, stabbing at the starter button again and again. The others stood around, dazed and numb.

"I guess we'd better check the circuits first," Charles muttered and lurched out of the car. For two hours the weary men fumbled over the engine, trying to find the trouble. Finally Charles sagged down on the running board. "Boys," he said, "I'm stumped."

Bob DeMaree shook his head to keep his eyes open. "I think we're all so beat, Boss, that we can't see the trouble staring us right in the face. Why don't you give Bill Chryst a call?"

Charles telephoned Bill at his job at NCR. He left the plant at once and hurried over to the barn.

Half an hour later Bill found the trouble in the controller switch on the battery. With Bill's help Charles tore down the switch and rewired it. At 6:30 they finished re-installing it.

Once more Charles climbed into the automobile and put his thumb on the starter button. He let out the clutch. Pure music burst from the car's engine.

The sound of the engine's roar was drowned by the joy-

ful shouts of the barn boys, who immediately dropped in their tracks. Charles and Bill pointed the car for the railroad station to get it on the late train for Detroit. Several times on the way to the station Charles stopped the engine and started it "just to be sure," he told Bill, "that the danged thing works."

With the automobile safely berthed in a freight car, Charles stumbled into a sleeping car and collapsed, too exhausted to undress. Early in the morning of February 17, 1911, the porter shook him awake and helped him off the train. Charles, in the first automobile in the world equipped with a self-starter, drove to the Cadillac plant just in time to take Leland for a demonstration ride before he left for Bermuda.

The test delighted Leland. Before Charles took the return train home he sent the gang a telegram:

ORDER FOR 12,000 STARTERS FROM CADILLAC
CINCHED STOP ARE WE DOWNHEARTED STOP NO
STOP DELCO

Since confirmation of the contract for starters depended on results of exhaustive tests by Cadillac, Charles left the car with Herman Schwarze, a Cadillac engineer, for testing. Back at home again he built another starter and installed it in his own Cadillac.

Leland requested that the storage battery should provide electricity for the ignition system as well as the starter. "And I want you to provide current so that I can use electric lights on the car and get rid of the acetylene lamps," Leland said.

Charles tinkered and tested on the ignition and lighting systems. He drove the car all over the countryside around Dayton, seeking the roughest roads he could find, trying to jolt the starter or ignition systems right out of the car. One

evening when he hit a rough jut in the road, the lights went out. "Dandy!" he exclaimed and drove home in the dark. It was late when he got to the house. He looked the car over for a time but went to bed without finding the trouble.

About two o'clock, he sat up suddenly, "I've got it!" he shouted. "I've got it."

"What? What's the matter?" Olive murmured, yawning out of a deep sleep. "Burglars?"

"Gosh, no!" Charles exclaimed, hopping out of bed and grabbing for his trousers. "I bet it's the ampere-hour meter."

"Good grief," Olive said in a disgusted tone. She rolled over and said no more.

Charles arrived home in time for breakfast. "I fixed it," he reported happily. "I put a shunt around it." Olive glared at him.

Poor Olive! She lived a lonely life. She never knew when Charles would be home for meals or to sleep, and when he was home his mind toyed constantly with the coils and sparks. It was a hard life for a woman with a warm affectionate nature. But with Charles for a husband that is the way it had to be.

For a day or two it looked as if Olive might get her wish to have him home for a while. Out driving one early spring day in April, he slammed on his brakes, hit an icy patch in the road, and skidded into a ditch. The car was wrecked. Somebody brought Charles home with a broken ankle.

Doctor McCann put a cast on the leg and told Charles to stay in bed for two weeks. "Don't you dare stir one step," he cautioned Charles. "Olive, he must not get out of that bed."

He did stay in bed the rest of that day and night. But the next morning a delivery boy brought a telegram.

GARAGE FIRE LAST NIGHT DAMAGED TEST CAR

STOP STARTER DOES NOT FUNCTION CAN YOU
COME STOP LELAND

"This is one time you won't be hopping on the next train," Olive said, "I'll send him your reply."

"You will not send a reply," he told her, swinging his leg, cast and all, out of bed. "Bring me my trousers."

"Charles Kettering, you aren't thinking of going to Detroit!"

"I am not thinking of it, I'm going," Charles said.

"But you know what Doctor McCann said!"

"McCann be hanged! Please get me my trousers! And find out where I can get some crutches!"

Next morning, Charles hobbled on crutches into the Detroit garage where the test car was kept. Stretching out on a wheeled platform, he rolled himself under the burned car.

An hour or so later, grease from top to toe of cast, he rolled out from under the car. "Try her now, Herman," he said to Schwarze, who was working with him.

Schwarze turned on the switch. The engine started. Charles leaned on the crutches, hobbled out of the garage, and headed for home.

Schwarze gave the test car every kind of punishment he could devise. Sometimes the ignition coils broke down. At other times the relays stuck or the starter shorted out. But finally the breakdowns came less and less frequently.

In Dayton, Charles tested his own car, driving it over all kinds of roads in all weathers. One day when he drove an engineer from Detroit to catch a train, he parked and walked into the station with the visitor. As he crossed the lobby he noticed Thomas J. Watson, then sales manager of NCR, coming from the train.

"Wait for me, Tom," he called, "I'll drive you home."

Watson waited. When Charles joined him, the two walked to the car, reminiscing over old days at NCR. "Here she is," he indicated, pointing to his roadster parked behind the station.

Watson got into the front seat beside the steering wheel while Charles walked around in front of the car and climbed into the driver's seat.

What happened next became one of Watson's favorite stories even after he left NCR and became head of International Business Machines Corporation, NCR's strongest competitor. "Boss Kettering's certainly got to be an absent-minded inventor," he thought. "He forgot to crank the car. Will I ever kid him when he wakes up!"

But Charles slammed the car door shut, fiddled with the gas and spark levers, and pressed a button. The engine started.

Tom Watson just about fell out of the automobile. "Good gosh!" he exclaimed. "What happened?"

"I started the engine," Charles grinned.

"But—but you didn't crank it!"

"That's right. My battery cranked it for me. Like to see?"

They got out of the car, and Charles showed Watson the self-starter. "I guess you're the first person outside of the company to know about this," Charles told him.

As long as he lived, Tom Watson cherished the memory of that moment of surprise behind the railroad station.

When Herman Schwarze finally was satisfied with his test results in Detroit, he wired Charles to begin sending starters for the 1912 models. The orders put Charles on the spot.

He had supposed that the Kellogg people in Chicago, who had made his ignition sets, would also manufacture the starters. But Edwards at Kellogg turned him down.

"Setting up for such a big job is too expensive," Edwards told him. "Besides, it's too risky. Your starter might turn out to be a dud."

Charles talked it over with Deeds. "There's only one thing to do," he said, "and that's to make the sets ourselves."

Edward agreed. "It will take lots of capital," he said. "More than we have."

"You believe in this starter?" Charles asked.

"Yes."

"Then let's put all we have on the line."

They moved all their equipment from the barn to the second floor of the Beaver Power Building at Fourth and St. Clair streets. To get money to buy additional equipment for the factory, Charles mortgaged a lot he owned, Edward mortgaged his house, both borrowed on their life insurance and used their patents and contracts as collateral for the bank loan. They collected some money in advance from Cadillac and because they still needed more money, they sold some preferred stock in Delco.

When Cadillac began to advertise the new Delco self-starter, lighting system, and ignition, the news caused a sensation in the automobile world. As soon as the new models began to appear in dealer showrooms, crowds flocked.

But once more trouble started. Leland telephoned from Detroit. "I am greatly disturbed," he said. "Our Cadillac dealer in Pittsburgh has informed us he will cancel his 1912 contract with us unless we abandon the Delco ignition and go back to magneto."

"That so?" Charles commented, his eyebrows quirked.

"He says he made a test and the car has better pickup and more power on the hills around Pittsburgh on magneto than on Delco. Now he is a very influential man, Mr. Ketter-

ing, and his complaint greatly disturbs us. I am going out to Pittsburgh this week to see a demonstration."

"Mind if I meet you there, Mr. Leland?"

"I'd be very glad if you would."

A few days later in Pittsburgh Charles met Leland, his son Wilfred, and Walter McKechnie, a Cadillac engineer. The four went to the dealer's office and met him and a man from the magneto factory.

They all went for a test drive in a Cadillac fitted with both the Delco ignition and magneto. Charles chose to sit in the front seat with the magneto representative, who drove.

Choosing one of Pittsburgh's hilly roads, the magneto man drove the car on battery. Near the top of a long hill the engine stalled. Then he took the car to the bottom of the hill, switched to magneto, and started up again. On the second trip the car surged smoothly to the top with nary a snort or quiver.

Again and again on different roads the magneto representative demonstrated how the engine stalled on battery but not on magneto. All morning Charles sat quietly, watching closely every move the magneto man made.

As test after test showed the superiority of the magneto, Leland and his party began to look concerned and discouraged.

"I will say that the tests look pretty convincing," Leland admitted when the Pittsburgh dealer pressed him for a comment. "It's getting near noon," he went on. "Let's all go somewhere and have lunch and talk it over."

The driver stopped at a restaurant and all the men got out. "You fellows go along," Charles told them. "I'll join you directly. I want to check over the battery connections before I eat." The magneto man gave Charles a sly look

as if to say he understood why Charles had lost his appetite and followed the others into the restaurant.

After a while Charles joined them. "Anything wrong with the connections?" Leland asked Charles.

"Nope. Fine." Charles looked noncommittal and started studying the menu.

After lunch Leland asked for one more demonstration. Again the same results showed the superiority of magneto over battery ignition.

"Think we might as well go back to the showroom," Leland said finally. "I am convinced."

Charles sat quietly by the driver while he drove back to the dealer's office. When they arrived, the men got out and gathered in a little group by the automobile.

"I am very much afraid, Mr. Kettering," Leland said, "that these tests show without a doubt that the magneto is superior to your battery system. I am certainly sorry to disappoint you, but I must have only the best for my car."

Charles stared owlishly through his spectacles. He saw the magneto man smiling. "As you say, Mr. Leland," Charles said, "these tests do seem conclusive. I have a question, though, that I would like to ask of this representative of the magneto interests." He turned to the driver. "How do you explain this? This morning the car performed better on magneto than battery, but this afternoon it did just the reverse. This afternoon it performed better on battery than magneto."

Henry Leland pricked up his ears.

"Oh, no, you are quite wrong," the magneto man said airily. "It was on magneto this afternoon when it operated so smoothly. See, the switch is still on magneto."

"That may be," Charles said, "but it is actually on battery.

Here. Look." He opened the hood and pointed inside. "While you were at lunch, I switched the connections to the battery and magneto. See?" He showed them what he had done.

"But I don't understand," the dealer protested.

"This afternoon the car actually stalled on magneto and drove smoothly on battery." Charles blinked at them through his glasses.

"But why? How?" Leland demanded.

"Actually, as every Cadillac driver knows," Charles explained, "the carburetor on this car has a tendency to stall if the gas is fed too fast but not if it is fed gradually. I noticed this morning that when the car was operating on magneto, you," and he turned to the magneto man, "were easing the gas into the engine. But when you switched the car to battery, you jammed your foot down on the accelerator. That is why the engine stalled." He threw back his head and laughed.

The magneto expert glared at Charles, his face turning red. "You gentlemen will excuse me," he said, and jumped into his test car. The dealer, who had been completely fooled by the magneto expert, apologized at great length while he drove them to the railway station.

"Just what gave you the idea of watching that fellow's accelerator foot?" Leland asked Charles. "I never would have thought of it."

"I remembered something I heard in a washroom coming home from Chicago," Charles told him. "I've been expecting to hear from the magneto people."

By now it was August, 1911. The public bought every Cadillac as fast as it was delivered from the factory. For the first time women could safely drive an automobile.

It was because of Kettering's self-starter that women's fashions in 1912 changed radically. The long skirts got in

the way of operating accelerator and brake. They went. Into limbo, too, went the petticoats, the hourglass corsets, and the wide hats.

The Royal Automobile Club of England awarded the Dewar Trophy to Cadillac for the new ignition and starting system. No other automobile has ever won the Dewar Trophy twice.

Alex Dow, president of the Detroit Edison Company, invited Charles to talk about his starter to the local branch of the American Institute of Electrical Engineers. Except in school Charles had never made a talk in public before.

"What are you going to say to them?" Olive asked him as he packed his bag.

"I don't know. I'll make up my mind after I get there."

They gave him a blackboard to use and let him set up his drawings. He told the engineers why he did what he did.

At the end of the speech Charles stopped for questions. One man arose and said:

"I move that this meeting come to a close. This man doesn't know what he is talking about. He has profaned every law of electrical engineering."

"What law have I profaned?" Charles asked.

"You are using more current through the wires than the formula allows."

"I am not interested in what the formula allows," Charles said. "I am interested in starting an automobile and it has worked out quite well."

The man snorted and sat down.

Before he left Detroit, Charles was invited to dinner at the Detroit Athletic Club, the center of all social activity for automobile men as well as other leaders in Detroit industry. After dinner a tall, wiry man walked up to him.

"I'm Henry Ford," he said, shaking hands. "Young man,

I am not going to put your starter on my automobiles."

Charles smiled into the blue eyes of the leader of the automobile world. "I think that the future will take care of that, Mr. Ford."

9

❧ Cadillac had the self-starter on its 1912 model, and the following year Delco made them for six other automobiles in addition—Cole, Jackson, Hudson, Oakland, Oldsmobile, and Packard.

Bill Chryst left his job at NCR to become plant superintendent. The number of Delco employees jumped from 12 to 1200.

Charles paid off the mortgage on his lot and the loan on his life insurance. When Edward decided to buy a farm on the south edge of town, Charles bought some acreage adjoining. Part of the land they made into a recreation park with cottages and a swimming pool for Delco employees.

"We'll build ourselves a handsome house," Charlie told Olive. "You start thinking of all the things you would like to have."

Olive still kept her husband informed of the news. The biggest news story of the year was the *Titanic* sinking on April 12.

The following month, on May 30, Wilbur Wright died of typhoid fever. "A great loss to this town and to aviation," Charles commented when Olive read the news to him. "You know, I've been thinking for some time that I ought to go out to the Wrights' flying school and take some lessons."

Olive put down the paper.

"You mean you would go up in one of those contraptions, Charlie Kettering? Why? Why? Why?"

ing levees along the banks of four streams that join within Dayton broke, and rivers carrying two and a half times their normal amount of water spilled over into the city.

About ten o'clock on the morning of March 25 Charles found a telegram waiting for him at the Kellogg plant in Chicago.

DAYTON FLOODED 27 FEET OF WATER IN DELCO
PLANT STOP BILL CHRYST.

"My great gosh!" he exclaimed, handing the paper to Anderson. "The plant flooded! All those orders for starters! All that machinery! Our production schedules! And our families! Bill, we've got to get home!"

They packed their bags and jumped aboard the next train. They picked up what scraps of information they could gather as their train moved eastward from Chicago. Millions of dollars of damage had been done. Thousands of persons were marooned in their attics. Hundreds had perished.

Charles felt certain that Olive and Gene were safe, for Lexington Avenue, though only four blocks from the river, was many feet above the levees. Of course, they would be frightened. He was sorry not to have been there on that account.

At Richmond, Indiana, the station master shook his head. "The tracks are under water east of Richmond," he told them, "and it's raining harder every minute. There'll be no trains east out of town for several days at least."

"But we have to get to Dayton!" Charles told him.

"Dayton has been wiped out," the man said.

Charles doubted that, but if it had, he still had to get there. Grabbing their bags, they set out on foot in a vicious rain for the center of town. By the time they found an automobile for hire, they were walking sponges, but they headed east on the National Road.

Rain fell heavier and heavier as they moved slowly eastward. The isinglass curtains on the automobile leaked, and Charles' arm ached from working the windshield wiper back and forth. Their headlights sent forth puny beams. Both men sat on the edge of the leather seat peering into the wet blackness. They met no other travelers. It was as if they were the only people in the whole wet world.

At Lewisburg, about eighteen miles from Dayton, Charles slammed on his brakes. The car slithered to a stop. "Great gosh, look!" he shouted, pointing through the windshield.

"What?" Bill shouted over the noise of the rain on the canvas top. "What happened to the road?" Ahead of them was nothing but churning brown water.

"There ought to be a bridge here over Twin Creek," Charles said. "Can you see it?"

"I'll take a look." Bill climbed out and sloshed a few feet ahead of the car. "There's nothing out there but water," he said when he came back. "I suppose the bridge is out. Now what will we do?"

"Your eyes are better than mine," Charles told him. "Take a look over to the left and see if you can locate the railroad bridge."

"Does the railroad run along here?" asked Bill.

"Sure. We crossed the tracks about fifty yards back. Remember?"

Bill nodded and disappeared in the darkness. After a long time he came wading back. "Railroad bridge is still up," he reported.

"Hold on," Charles said and started backing down the highway. When they recrossed the railroad tracks, he swung the wheels and drove off the road onto the crosstie bed.

The tires bumped fearfully as he urged the car along the railroad ties. Finally they approached the bridge, swaying

over vicious waters. "Think we can make it?" Bill wondered.

Charles clamped his teeth on his soggy cigar. "Let you know shortly," he said, feeding the gas to the engine. They thumped along gingerly until at last they reached the other side where they could see mud between the ties instead of empty air. "Wow!" said Charles.

It was still raining at midnight when they hit Salem Pike. At half-past twelve they reached the first houses of the town.

"Guess everybody's gone to bed," Bill remarked, looking at the dark houses.

"More likely there's no electricity," Charles said.

At Grand Avenue, Bill left the automobile. He could walk home from there. Charles pulled into Lexington and parked the car in front of the dark apartment house.

Olive cried when he stuck his head in the door and called, "Is anybody home?"

"It's just awful," she sobbed as he put his arms around her. "I've been so worried about you."

"Is Gene all right?"

"Yes. He's asleep, but I had a hard time getting him to go to bed. He's only four, but he knows something is wrong. There aren't any lights, Charlie, or water or telephone. I've just had to sit here in the dark and worry."

"Well, it will be all right now, Olive. You just go to bed and don't worry any more. I'll get some dry clothes on and go down to the plant."

"The whole downtown is under water," Olive said. "You can't get across the bridge."

"Then I'll go down to the firehouse and see if there is any news. Maybe I can help."

"Not the firehouse. They've set up headquarters at Long-

fellow School. Gene and I went down there this afternoon and helped with the people they were bringing out in boats. We brought a family home with us. They're in our bedroom."

"Then I won't change clothes. It's raining so hard I'd get wet through in a minute, anyhow. Good-by. I'll be back before morning, I expect."

When he walked into Longfellow School, he saw a man evidently in charge of rescue operations working at a desk in the hall by the light of a smoky kerosene lamp.

"That all the light you have?" Charles asked.

The man nodded. "We've taken about seven thousand people out of their homes in boats today," he said. "We're finding homes for them. I'm trying to keep track of where we send them, but it's almost a hopeless job."

"You need light," said Charles.

He hurried out into the rain and commandeered three electric automobiles he had noted parked on the streets as he walked down Salem to the school. After he parked the cars in the alley behind the school, he fetched wire and tools from the barn, and wired the batteries together. Soon the schoolhouse had electricity.

The man in charge came out to thank him. "My name is Smith," he said, offering his hand. "George B. Smith."

"Charles Kettering," Charlie told him.

"Oh?" the man exclaimed. "I've heard of you, Mr. Kettering."

Charles grinned. "I'll be back tomorrow to help, Mr. Smith," he promised.

After a few hours' sleep on the living-room floor, Charles drove down to the schoolhouse to report for duty, taking with him Bill Chryst, who had stopped to check on the Ketterings. Matters were worse, he found, than they had been

the night before. Food supplies were running low. Fires were breaking out in downtown buildings above the water line. Looting had begun. The city had no means of communication by which to call for help from the outside world.

Smith had written a telegram to James M. Cox, Governor of Ohio, asking for troops, food, medical supplies, and boats. "I want three volunteers each to take a copy of this message to a telegraph station somehow and get the message through to the governor," he said.

Charles took one of the copies. He and Bill, both dressed in rubber boots, coats, and hats, headed north in the driving rain in a buckboard automobile with no top, no dash, no fenders, and no body except for two seats and a floor board. To get to the telegraph lines they had to cross the river. Charles planned to drive northward along the river until he could find some way to get across. They drove for what seemed hours past one washed-out bridge after another. The rain began to turn to sleet.

To the north of the city he found a railroad bridge still standing. "Here we go," he sang out, turning the wheels on to the track bed.

Bill turned pale. "You aren't going to try to cross there, are you?" he gulped.

"Have no fear," Charles told him. "I've had experience."

The car rattled merrily across the open crossties, but refused to go one inch once the bridge was left behind.

"Out of gas?" asked Bill.

"I don't think so. More likely a wet carburetor. Got a dry handkerchief?"

Bill found one. Charles climbed out of the car, waded around to the hood, opened it, and wiped the carburetor dry. With the engine going once more, they drove northward until they saw the light of a railroad dispatcher's tower.

The men, their rubber coats shining with rain and ice, burst in on the dispatcher. "Have you a telegraph line open?" Charles asked.

"Yes. One."

"Then for the love of all that's holy get this message to Columbus right away." He thrust the paper into the dispatcher's hand.

"But I have no line open to Columbus," the dispatcher said.

"Then relay it through by way stations," Charles urged.

The dispatcher finally was able to get the Tiffin operator on the wire, who relayed the message to Delaware, from where it was relayed to Columbus.

They arrived back in Dayton at daylight. Help from the governor came that same afternoon.

On Friday morning the water had gone down sufficiently that Charles could wade through muck and debris to the Delco plant. The sight discouraged him. Two floors were buried in four inches of muck, slime, and oil.

Furniture, files, office equipment, and machines were stacked crazily on their sides and tops, soggy, dirty, and rusty. In the stockroom he found a dead horse.

He hired a fire-equipment manufacturer in Cincinnati to pump water out of the basement. As soon as telephone service was available, he began calling the employees to report for cleanup duty.

"Tell me your home address," he said to each workman who straggled in. "We will do all we can to restore your home and furnishings. Meanwhile we want you to remain at the plant to help us get back in production."

He hired squads of carpenters, plasterers, plumbers, and electricians, and set them to repairing the homes of workers. Every bit of damaged furniture in the home of every Delco

employee he replaced with new. He bought twenty-five prefabricated homes from a company in Chicago and set them up in Delco Dells, the company recreation park, for the executives who had lost their homes.

Within a few weeks the company resumed production. The 1913 automobiles were only briefly delayed.

One morning at the Delco plant, shortly after the flood, Charlie opened a letter from a Cadillac owner who had used the lighting system in his automobile to provide temporary lights for his summer cottage. He wanted to know whether he could buy a separate electrical system to use in his cottage, which was far beyond the power lines.

Charlie had been sitting in his favorite position, low on his spine. Now suddenly he sat erect and reached for a pencil and a piece of drawing paper. Why hadn't he thought of it before? Hadn't he provided some lights at the schoolhouse during the flood by using batteries from electric automobiles? And hadn't he promised his mother that she would have an electric washing machine and iron and electric lights and electric pump and a vacuum sweeper? It ought not to be too difficult, he figured. All he needed was a string of batteries and a generator to charge them. And when he got it working right, he could make more sets and sell them to farmers all over the country. Why, when farmers had electricity, who would want to live in the city?

He strung a series of batteries together and attached a one-cylinder gasoline engine to it. With the hookup he could provide 32 volts of electricity.

Martha Kettering was ironing in the kitchen the morning Charlie drove into the barnyard in the Delco truck. He slipped quietly up on the porch, peeked into the kitchen and said softly, "Hello."

Martha looked around. "Well, for goodness sakes, Char-

lie," she exclaimed, setting her sad iron back on the stove. "Where did you come from?"

"Come on out in the yard and see what I've brought you," he invited, slipping an arm around her waist. "A big surprise."

Together they walked out to the truck. He had brought all the materials for wiring the house and barn, two electric pumps, one for the house and one for the barn, a washing machine with its electric motor on the floor beside it, an electric iron, a fan, and a vacuum sweeper.

Martha stood speechless while her son pulled each new wonder from the truck. "Oh, my, we must get your father in from the fields," she said.

"I'll ring the bell for him in a minute," he said. "I need him to help me with the wiring. He's a better carpenter than I will ever be."

"But, Charlie, those things must have cost a fortune!" his mother exclaimed, running a work-gnarled hand over the washing machine. "We can't afford them."

"They're yours and they're all paid for. I promised you, didn't I?"

Jacob Kettering, his beard grizzled now, his back somewhat stooped with years, came in from the field to answer to the summons of the dinner bell. "What's wrong?" he asked, hurrying up on the back porch.

"Nothing's wrong," Martha told him. "Charlie's here and he needs you to help him."

"Charlie." The two men shook hands.

Like a little boy who won the prize in a spelling bee at school, Charles showed his father all he had brought. "I've put some marks on the walls and ceilings for the fixtures and switch boxes," he explained. "I thought you might cut the holes while I string the wires where they should go."

Jacob nodded and got his saw.

The two men worked all day. Although not all the wiring was finished that night, Martha Kettering that evening became the first farm woman in the United States to sit down in her own parlor and read the newspaper by her own electric lights.

Charles stayed at the farm several days, sleeping in his own feather bed in the corner bedroom, until he completed the work. "Now there's one thing wrong with this system," he told his folks as he was getting ready to drive back to Dayton. "After you have used the electricity for a while, you will have to run the generator to charge the batteries. The trouble is, it's hard to tell just when to start the generator. One of these days I'll work out an automatic system in which the engine will start whenever you use any electricity."

He was right. Sometimes Jacob forgot to charge the batteries and then Martha got out the kerosene lamps. But nothing in the world had ever happened half so wonderful to Martha Kettering as the first time she pressed a button in her living room and had light. "It's a miracle," she told her son.

Architects were busy with the plans for the Ketterings' new home, Ridgeleigh Terrace.

For the site Olive and Charles chose the top of a wooded hill overlooking a pleasant valley to the front and Moraine Farm to the back.

Partly because he hated the hot, humid summers in Dayton and partly because the new home was to have a music room with the very finest pipe organ he could buy for Olive, Charles wanted the new home to be air-conditioned. But when he spoke to the architect about it, the man threw up his hands.

"Air conditioning in a private home? I never heard of such a thing!" he exclaimed.

"You have now," said Charles.

"It just isn't done. You aren't living in a theater, you know. I read lately that some department stores in the East are going to put in some kind of cooling system, but you just never would do any such thing in a private residence."

"You are planning to warm the air in my house in the wintertime," Charles pointed out. "All I want you to do is cool it in the summer. You can use the same ductwork, I should think, and the same fans. The air can be washed and cooled by blowing it through jets of cool water. There's a spring on the place which will provide the water."

But the longer he talked, the more determined the architect became that he would have nothing to do with air conditioning. "Other architects would think I had lost my mind," he said.

Charles finally shrugged his shoulders and walked out of the architect's office. He sketched a system using the method of cooling he had outlined to the architect and took the drawings to the contractor. Although he, too, had never heard of air conditioning a home, he agreed to follow the specifications and install the system.

When Ridgely Terrace was finished a year later, Charlie, Olive, and Gene moved into the first air-conditioned home in the world.

Now Charles began thinking about an idea that had been rattling around in the back of his mind. He had learned that several automobile manufacturers were going to increase power in the 1914 models by going from 4 to 6 cylinders. But Henry Leland had made the statement that Cadillac would never go to 6 cylinders.

"We will get more power by putting a two-speed rear axle on our 4-cylinder model," he said in an interview.

Charles knew that Edward had used a two-speed rear axle on his Suburban Sixty with very poor results.

"I am afraid that Leland is going to lose out in the power race," he told Deeds one night. "I was wondering what you would think of our going ahead and developing a more powerful engine for Leland on our own and, if he likes it, give it to him as a kind of thank-you for all the wonderful things he has done for us."

"That's a splendid idea," Edward said. "Count me in on it."

Edward's new home on Moraine Farm had already been completed. He had built a model dairy barn as part of his establishment.

"I can turn the cows out of the barn," he now offered. "You can work there and nobody will be the wiser."

Together they cleared out the dairy barn and fitted it with tools from the old barn on Central Avenue. Then they left for the 1913 New York Auto Show.

At the show Charles saw a French automobile with an 8-cylinder engine. "That gives me an idea," he said quietly to Edward. "Why don't we just go all the way and design an 8-cylinder engine for Leland while we are at it?"

Edward agreed, and they bought the French car and shipped it to Dayton. But after some tinkering Charles decided the engine was too unwieldy and heavy to suit the Cadillac.

Edward had a friend in California who had mounted an 8-cylinder airplane engine in an automobile chassis just for fun.

"Buy it," said Charles.

Edward telephoned the man, arranged to buy the car, and

told him to send it by express to Cincinnati. Shortly after he finished the conversation, the telephone rang. A telegraph operator read a rather incredulous wire over the phone:

"ARE YOU SURE YOU MEAN EXPRESS?"

As soon as the car arrived in Cincinnati, Charles went down to bring it back to Moraine Farm. He drove it at night and by the back roads. Once in the barn he dismounted the engine and put it in a Stevens-Duryea body. Old Steve, as Charles called the car, was kept under blankets except during the hours he worked on it.

Once he was satisfied with the engine, Charles telephoned Leland and asked him to test it. Since secrecy was necessary, Leland agreed to test the engine in Toledo.

Leland was so delighted with the tests that he decided to drop his two-speed axle idea in favor of the extremely powerful 8-cylinder engine. He rented a shop in Worcester, Massachusetts, and hired a man from England to design a new Cadillac around the engine.


Leland's 1914 Cadillac stole the auto show in the fall of 1913. Other manufacturers with their new 6-cylinder models felt that he had jerked the rug from under them.

"Now what do I owe you for all your work?" Leland asked Charles at the show.

"Not one cent," Charles told him. "Mr. Deeds and I want you to accept it as an expression of thanks for all you have done for us."

Leland's blue eyes filled with tears. He said, "I never thought to find such generosity among men of industry."

10

 In the old family Bible where Jacob Kettering had recorded in his spidery script the names of his children as they were born, his was the first death to be recorded. Charles wrote the date: February 27, 1914.

It was the first time for many years that David, Adam and his wife, Charles and Olive, and Emma and Daisy and their husbands had gathered together.

"We don't intend to let mother stay alone," Daisy told Charles at the cemetery. "We will move in with her and look after the farm if it is all right with you and the rest."

Charles felt happy to know that his mother would not be alone. "I would like to build mother a new house, everything strictly modern, if she will let me," he told Daisy.

"I'll talk to her and let you know," his sister promised.

But Martha Kettering refused to part with the old farmhouse she had lived in so long. She did, however, allow her son to add on to it and modernize it, but all the building had to be done around the original house.

Charles and Olive's house, Ridgeleigh Terrace, was now completed and beautifully furnished, and the Ketterings moved in. Gene started to private school, his mother driving him back and forth in her electric automobile.

The world began to shrink in 1914. In May, music was broadcast for the first time over the radio from the roof of the store in Philadelphia to the Wanamaker store in New York.

Late in June in Europe, at Sarajevo, Bosnia, the heir to the Austrian throne, Archduke Francis Ferdinand, and his wife were assassinated, an event that sparked World War I and set in motion events that inevitably drew the United States into the conflict.

At home Henry Ford brought out his one millionth automobile, still without a self-starter. Delco's business did not suffer, however, because Henry Ford was not a customer. The company erected a new seven-story building across the street from Plant I.

Edward Deeds resigned his position at NCR because Delco's business demanded his full time. He and Charles shared a handsome double desk in their office, but neither man had much time to sit at it.

For some time officials of the United Motors Corporation, a group of automotive parts companies, had been discussing the purchase of Delco. Charles was quite willing. He had never wanted to be a manufacturer in the first place. All he ever wanted to do was to tinker around and find new products to make the world more comfortable for people.

He spent his days on Delco problems. Nights he stayed at the plant to iron out the bugs in the farm-lighting outfit. He had no time to spend with his family or in the handsome greenhouse he had had built at the foot of the hill on which his home stood. He still wanted to find out how plants grow and why he could see through glass and how a magnet works, but there was no time.

Staying late nights, Charles improved the farm lighting system by installing an air-cooled, one-cylinder gas engine that automatically charged a series of 16 batteries. As soon as he worked out a few more bugs, the outfit would be ready to market.

One morning Deeds stopped by Charles' bench. "We have

had a firm offer from United Motors. Do you think we ought to sell?"

Charles didn't look up from his work. "It's all right with me."

"Want to know how much they have offered?"

"Umhum."

"They will pay, part in cash, part in stock, the exact sum of nine million dollars."

Charles went right on working. "That's a heck of a lot of money," he said.

It was so much money that neither man could take care of it. They hired George B. Smith, a Dayton manufacturer and civic leader, to devote his full time to handling their financial affairs. It was Smith for whom Charlie had strung the lights and delivered the telegram during the flood.

Charles kept right on working at his bench while Deeds and Smith handled the details of the sale. Both partners retained their jobs as administrators of Delco's affairs.

They opened an office in the City National Building where papers were drawn up for the Domestic Engineering Company, which was to market the Delco-Light farm lighting system. Richard H. Grant, a top NCR salesman, became sales manager for the new product.

But as soon as farmers began using Delco-Light, complaints began pouring in from all over the country. The valve in the little one-cylinder engine stuck.

Olive brought Charles his supper at the Delco plant while he tried and failed and tried again to find out the reason for the sticking valve.

Late one night his never-too-even temper exploded from fatigue and irritation. "The gol-darned thing!" He picked up a piston and hurled it across the room with such force that it smashed against the concrete wall.

Feeling a trifle better, he gathered the pieces and dropped them on the bench. Then just for the heck of it he measured the cylinder walls. Aha! The walls were $\frac{1}{8}$ inch thinner than his drawings specified.

Now he knew why the valve stuck. In use the cylinder walls heated too fast, allowing them to expand. When the valve was forced up into the narrowed space, it stuck.

Another bug, not nearly so easy to find, developed.

Because insurance laws prohibited farmers from storing more than one quart of gasoline at a time, Charles switched to kerosene for fuel. Unfortunately kerosene produces louder engine knock than gasoline. When farmers turned their lights on, *bang! bang! bang!* rattled through the house. The noise woke the baby, scared the cattle, cracked the plaster, gave the women ragged nerves, and caused the engine to lose power and stall.

Charles found one way of lessening the knock was to lower compression. The cure, of course, reduced the power also.

Engine knock was his old enemy. Automobile drivers still were experiencing the knock and loss of power every time they accelerated or tried to go up a hill. Magneto manufacturers still called it spark knock and blamed Kettering's ignition. But Charles knew that the knock did not come from battery ignition. He had tried magneto ignition. The engine still knocked.

He bought a Dobbie-McInnes indicator, a machine which, when attached to an engine, showed what happens inside a cylinder. But business demands took all his time, and the indicator found its way into the office closet.

With Edward Deeds and another Daytonian, Adam Schantz, Charles bought 882 acres south of the city, 500 of which was set aside for an industrial town to be called

Moraine City. The remaining acres were to be used for factory sites. The Moraine Development Company was incorporated to handle the project. Charles served as a director.

At about the same time he and others organized the Dayton Research Laboratories. Dr. Frank Clements, who had been Charles' chemistry laboratory instructor at Ohio State, became research director.

The Domestic Building Company, another organization of which Kettering was part, bought 97 acres from Moraine Development and constructed on it a 270 x 1000 foot factory to serve as the Delco-Light plant.

For a long time Charles had wished that he could do something for Loudonville, his home town. A young man, Hugo Young, had started a small business making sidecars for motorcycles. Foreseeing a future in the business, Charles supplied \$180,000 to expand the business of the Flxible Side Car Company, which later became the Flxible Company.

When the demand for sidecars fell off, Young began making ambulances, funeral coaches, and later small passenger buses for airports.

When Kettering first made his offer to Young, he thought that an annual income of \$300,000 for the company would be good. Now the company does a yearly business of more than fifteen million dollars.

One day Charles walked by the desk of a young man who was just starting to work at Delco, Thomas Midgley, Jr., a twenty-seven-year-old mechanical engineer, who had come to work at Delco because he wanted to do research. An idea struck him and he walked back to Midge's desk, sat down, and began talking about engine knock.

"Why don't you dig that indicator out of my closet, put it on a Delco-Light engine, and see what you can find out," he suggested.

The same afternoon, a Saturday, Midge found the indicator, unpacked it, and looked it over.

"That indicator throws a beam of light," Kettering pointed out. "Maybe we could get a picture of what goes on inside the cylinder."

Midge set up the engine, building a board enclosure around it to shut out the light. Charles made a film drum out of a tomato can, wrapped a piece of photographic paper around it, and placed it on pivots made of two shingle nails, fastened to two pieces of lath. While Midge ran the engine and indicator, Charles spun the tomato can so that the light beam hit the photographic paper. In this way they made pictures of what happened inside the cylinder during ignition and combustion.

Kettering had an idea that the knock occurred before ignition took place. The pictures showed that he was right. The knock was caused by a violent rise in pressure after the air-fuel mixture in the cylinder was ignited by the spark.

"Now why do you suppose kerosene knocks worse than gasoline?" Charles wondered aloud, rubbing his fingers through his thinning hair.

"Must be because of the rate of vaporization," theorized Midge.

"Then if we would speed up the rate of vaporization, perhaps we could eliminate the knock. Now you start looking for some chemical that will do that."

As he turned to leave, a thought struck him. He whirled around on his heel.

"You know, when I was a boy on the farm, I used to watch every spring for the first flower in the woods. Know

what it is?" Midge shook his head. "The trailing arbutus. I remember once going with my sister Daisy to pick some. I used to wonder why the arbutus blooms early, even before the snow was off the ground. I think perhaps it is because the red color in the leaves helps it use the sun's rays better than green-leaved plants do. Now, do you suppose if we colored the gasoline red, it might absorb the heat better, thus stepping up the rate of vaporization?"

"It's worth a try."

"Good. Let me know." Charles went back to his office.

Ten minutes later Midge shouted for him to come. "Listen, Boss!" he exclaimed as Charles hurried to his bench. The little Delco-Light engine was putting along evenly with never a knock.

Kettering's eyes sparkled through his glasses. "What did you use?"

"We didn't have any red dye soluble in kerosene in the stockroom so Fred Chase suggested that iodine would color it a sort of purplish-red. I tried it, and behold, it works!"

"It's almost too good to be true," Charles commented. "Let's check on Monday."

It was too good to be true. Midge made the rounds of supply houses on Monday and bought every kerosene-soluble red dye he could find. He tested each one in the engine, but the engine knocked as bad as ever.

"So it's not the red that did it," mused Charles. "Then it must be the iodine. Try it again."

Midge tried it. The knock stopped.

It would have been a simple solution to the problem if all gasoline manufacturers had to do was to add iodine to their product to make it knock free. But iodine is too expensive in the first place and, furthermore, forms iodides in the cylinder that will destroy an engine in a few days.

Midge wore a long face. "I guess we are back where we started," he said.

"No, we aren't," Charles told him. "If we know that one chemical can stop knock, you can be sure that somewhere there is another one that will. All you need to do, Midge, is look until you find it."

"Why don't we hire an expert chemist to go on this fox hunt?" Midge asked. "I don't know a thing about chemistry; I'm a mechanical engineer."

"That's precisely why you are just the man for the search," Kettering answered. "If we get an expert chemist in here, you know what he'll do? He will know so much about chemistry that he will spend his time telling us there isn't any such chemical. Midge, whenever you have a problem to solve, don't turn it over to an expert. He'll be too educated to solve it."

Midge grinned. "All right," he agreed. "Knock, here I come."

Knowing that the tobacco warehouse Midge had been using as a laboratory would not do for permanent quarters, Charles bought the old Grey Manor at 127 North Ludlow Street and fitted it up as a laboratory. There Midgley went to work with Thomas A. Boyd, Carroll Hochwalt, and Charles A. Thomas on his staff.

While the search went on, Charles kept busy on other projects. He and Deeds gave \$300,000 to build a clubhouse on Monument Avenue for young engineers and other men of science to use as a meeting place.

He kept up his interest in flying and communicated it to Edward, who built a flying field on part of his land south of town. The first private landing field in the country, South Field was used by Orville Wright for testing improvements on his planes.

One Sunday afternoon in January, 1916, Kettering and Deeds took Orville Wright for a tramp over a 120-acre tract adjoining Triangle Park, which they had previously purchased as an outing area for Delco families.

"You think this tract would make a good landing field, Mr. Wright?" Charles asked.

Wright agreed that it would. On his recommendation, the two men bought the acreage, including 209 lots in the city, vacated and razed the houses, tore up streets and curbs, cleared telephone and electric-light wires, cut down trees, dug up shrubbery, and put the landing field in shape. Named McCook Field, it was the first airfield to be opened within the limits of a city.

They built two hangars at the north end of the field, bought two airplanes, and hired Howard Rinehart to teach flying.

At about the same time Charles, Deeds, Talbott, and his son, Harold E. Talbott, Jr., organized the Dayton Wright Airplane Company, the purpose of which was chiefly research and experiment.

Early in March, 1917, Deeds stopped at Charles' desk. His face looked long.

"I have a letter here from the Secretary of War," he began, handing Charles a paper. "He wants me to come to Washington to serve on the Munitions Standards Board. It's for procurement of munitions and supplies."

Charles read the letter. "No pay, I see," he drawled.

"No, no pay. But if I can help, I am glad to contribute my services."

"That's like you," Charles said. "How soon do you figure we'll be in the war?"

"Very, very soon, I am afraid." Deeds stared out of the

window somberly. "It means I will have to pull out of Delco."

Both men realized at the same moment that their paths which had run so long together were about to part. Each man had been in his early thirties when they began to build the dam in the golden river. Now Charles at forty and Edward at forty-two, both millionaires many times over, had come to the end of their business association.

Edward said, "Those were good days back in the barn, Ket."

But Charles was never one to look back. "Good luck in the good new days, sir," he said.

They shook hands.

Two days before Deeds left for Washington, he and Charles, Orville Wright, Adam Schantz, and a few others met together and agreed to finance a private school suggested by Dr. Arthur Morgan, the engineer who had built the Miami Conservancy dams constructed around Dayton to prevent another flood.

Charles offered the use of his greenhouse for a building. "I'd rather raise kids than cucumbers," he told Morgan. With some remodeling, it served as the first home for the Moraine Park School. Eugene Kettering, now nine, became a member of the first class.

Edward and Edith Deeds moved to Washington, where he was commissioned a Colonel in the Air Force. They had scarcely left town when news came that the United States had entered the war against Germany.

Almost at once Charles' work at Dayton Research Laboratories was scrapped to free his time and facilities for war work.

He was given the job of developing the ignition for the new 12-cylinder, 440-horsepower Liberty airplane engine.

The government bought the new Delco-Light plant south of town and turned it over to the Dayton Wright Airplane Company for the manufacture of DeHaviland 4's, the new planes for the Liberty engine. Charles ground-tested the engines for the government.

But as soon as pilots began flying the new planes, his old friend engine knock was heard from. Government officials begged him to do something about the knock so that compression ratios in the engines could be raised to produce more power.

Midge and his staff were still looking for a chemical additive to eliminate knock. But war does not wait. "Let's look for the gasoline that gives the least knock," Charles suggested.

Collecting samples from all over the United States and even from foreign countries, the searchers found that gasoline made from California crude oil knocked much less than the gasoline from Pennsylvania crude used by the Air Force.

Charles recommended to the Washington committee that switching to California gasoline would enable the compression ratio to be raised one full point. But the committee turned down the suggestion as impractical.

"The surest way to kill a new idea is to submit it to a committee!" snorted Charles.

"Find some other way," the committee urged.

"If we can't get better gasoline, how about making synthetic gasoline?" he suggested. The committee agreed he should try.

He decided to make cyclohexane, a compound of hydrogen and benzene very similar in structure to the California gasoline.

"It can't be done," Dr. Leo H. Baekeland, world-famous

chemist on the committee, said. "I will give you a medal if you succeed in making one pint of cyclohexane."

"See what I told you about experts?" Charles grinned to Midge.

After many trials he and the team succeeded in hydrogenating benzene by using nickel as a catalyst. The synthetic gasoline had an octane rating of 75, 25 points better than the 50 rating of aviation gasoline then being used.

When Baekeland came to Dayton to attend the dedication of the Engineers' Club, Kettering presented him with a pint of cyclohexane and an artist's sketch of the proposed design of the medal.

Early in the autumn of 1917, Brigadier General George O. Squier, head of the Signal Corps, asked Charles to develop a robot bombing plane to be used against the Germans. He worked out plans for the Bug, as it was called, and had several models constructed at South Field. It had a papier-mâché and wood body with a 12-foot wingspread. Powered by a 2-cycle 4-cylinder 40 horsepower engine, the Bug could carry 300 pounds of explosive 50 miles to the target.

The Bug was launched from a track pointed in the direction of the target. Before each flight the operator calculated the number of revolutions necessary to take the plane to its target, allowing for wind resistance. When the engine turned the prefigured number of revolutions, a cam fell into place, the wings folded back, and the Bug plunged to earth, exploding its load of TNT. After tests at South Field proved successful, the Air Force ordered 40,000.

Late in the summer of 1918 Colonel H. H. Arnold, in charge of the Bug, left for France to make arrangements to


put it into action against the Germans. But an epidemic of influenza swept across the country and Arnold came down with it on shipboard and had to spend some time in the hospital at Southampton.

As soon as he was well, Arnold reported to General Pershing, but by that time the Armistice had been signed.

"Young man," Pershing told him, "that is a very important development. I would keep at work on it. You will need it in the next war."

When the Germans startled the world during World War II with their buzz bombs, Air Force Head General Arnold and Charles Kettering were two men not the least surprised.

11

 As soon as the war ended, Kettering very quickly went back to work on his old unfinished projects. In addition, he started several new ones.

He became president of the Society of Automotive Engineers in 1918, a position that required him to travel and make numerous talks. His speeches were always informal, pungent, and humorous, yet they were packed with good old engineering horse sense. His name as toastmaster or speaker began to appear on many programs.

As most of his engagements took place where he did not happen to be, he used his airplane for jaunts about the country. Flying in 1919 was still a new thing. Since most towns had no airfields, Charles took his chances landing in pastures or cornfields. In 1919 he flew over 15,000 miles. During the summer he and his pilot, Howard Rinehart, made an 800-mile, nonstop flight to Wichita, Kansas, a record at that time.

He made so many flights and so many speeches that sometimes he forgot just where he was going or why. One time when his plane landed in a field near St. Marys, Ohio, Charles asked the pilot, "Did my secretary tell you why I came up here? I don't remember what I'm supposed to do."

The pilot didn't know, either. They waited for a little while. Soon a car pulled up and a man hurried over to the plane. Charles found out from him that he was the speaker at a St. Marys club meeting that evening.

Planes of the day were dangerous because of the fuel pres-

sure system. If the pressure failed, the engine got no fuel. If a leak occurred in the line, plane and pilot went down in flames. Kettering removed the danger from his plane by substituting a fuel pump for the pressure system.

At South Field he had an experimental plane built with an all-cantilever wing construction of his design. It was the first plane in the country with retractable landing gear, which he also designed. He planned to enter the plane in an air race in France. As the deadline for shipping the plane approached, the workmen had trouble with the gears that moved the wing flaps.

Olive, by a carefully laid plan, had coaxed her husband to take her to the theater. To please her he had even put on a dress shirt and dinner jacket. When the two got into the automobile, Charles said to the driver, Ernest Bossuth:

"Ernest, stop over at the Field a minute on the way to town. I want to see how the boys are getting along."

Ernest parked by the plane. "I'll just be a minute, dear," he told Olive as he got out, peering up at the men working on the wing. He slipped out of his shoes and climbed up on the wing's thin skin.

A long time later the sound of the car horn brought him down. Walking over to the car, he sheepishly handed Olive the tickets.

"Here, Olive," he said, "you have Ernest drive you to the play. I have to stay here."

When United Motors took over Delco, Charles learned to know and like the company president, Alfred P. Sloan, Jr., who had become a vice president of General Motors Corporation when that company absorbed United Motors in 1918.

One summer day in 1919, Charles looked up from his bench to see Sloan standing in the doorway.

"Why, Alfred," he greeted him, shaking hands, "what brings you down from Detroit?"

"I have a proposition for you," Sloan told him.

Members of the policy planning group of General Motors had decided to establish a research laboratory in Detroit with the purpose of improving GM products and developing new ones. They wanted Charles F. Kettering to be its director.

"Will you take the job?" asked Sloan.

"No," said Charles; "I already have too many irons in the fire here in my own laboratory. Besides, I'm all bogged down with business interests that somehow I managed to get myself into."

No was not the answer Sloan wanted to hear. He offered for the company to take over all Kettering's business interests. He would then be free to do what he liked best—research.

After Charles thought the matter over, he agreed to take the job on three impossible conditions. He wanted no authority or responsibility. He wanted never to have to account for any money he spent. And the research laboratory had to be in Dayton, not Detroit.

"If I have to keep books on expenses or be held accountable for everything going on in the laboratory," he explained, "then I can't do research. I never know when I start looking for something whether I'll find it or how much it will cost or whether it will be worth anything when I do find it."

Few prospective employees had ever laid down such conditions to an employer. Certainly no one in General Motors ever had. But the policy committee wanted Kettering very much.

The General Motors Research Corporation was set up in

the old Dayton Wright Airplane Company building, just two hops from Ridgeleigh Terrace. The staff moved from the downtown building.

The old search for an antiknock agent continued in the new organization. Until it could be found, automobiles could not be improved powerwise.

In an internal combustion engine the power to turn the crankshaft which turns the wheels comes from the burning of a mixture of fuel and air in the cylinder.

Inside the cylinder the gas molecules formed by the mixing of vaporized gasoline and air bounce around. When the gas is fired by the spark plug, the gas molecules bounce so hard that they push down the piston, thus turning the crankshaft. The way to get a more powerful explosion inside the cylinder is to make the space inside the cylinder smaller by pushing the piston closer to the top of the cylinder. In the smaller space the molecules bounce harder and push the piston with greater power.

The distance the piston travels inside the cylinder is called compression ratio. In 1919 the ratio was 4 to 1, a ratio that gave little hill-climbing and passing power.

Manufacturers found that raising the compression ratio increased engine knock, so that until the knock problem could be solved, automobile progress had to wait.

Shortly after the team moved to its new headquarters, they found that nitrogen added to gasoline in the form of an aniline compound eliminated knock to such an extent that it could be used in an experimental car with 7 to 1 compression ratio, giving twice the power and 40 per cent better gasoline mileage than the 4 to 1 engine.

Charles tried the new agent in an experimental 7 to 1 Chevrolet. After numerous road tests he regretfully told the boys that aniline was no go. It failed to prevent knock at

extremely high speeds, for one thing. For another, the exhaust fumes smelled like an elderly unbathed goat.

Midge, who had been working for four years on the project, now asked Kettering to let him drop the search. He wanted to work on other research he had in mind, not spend all his life looking for a knock suppressor.

"A good research man fails every time except the last one," Charles told him. "If you fail nine hundred and ninety-nine times it doesn't matter. The thousandth time when you win is what counts."

"I have failed about three thousand times already," Midge pointed out.

"I have to go to New York this afternoon," Kettering told him. "When I come back, we'll talk about it."

Charles' speech in New York to the Society of Fuel Engineers was "Studying the Knocks," in which he revealed the cause of engine knock. The speech was reprinted in the *Scientific American* and caused great interest among automobile men and oil companies.

Coming back on the train after the speech, he picked up a newspaper to glance over the headlines. One caught his eye: UNIVERSITY PROFESSOR DISCOVERS UNIVERSAL SOLVENT. Charles chuckled. Anybody who found a compound that dissolved everything would have a hard time finding anything to keep it in. Curious, he read the article. The solvent was a compound of selenium.

Back at the lab he showed Midge the article and suggested selenium might be worth a try.

It was a happy thought, or so it appeared at first. Selenium had an antiknock effect five times greater than the aniline compounds. Tellurium ethyl, a compound similar to those formed with selenium, had an effect four times greater than selenium.

But as soon as the staff men began to run engine tests with tellurium, the rooms took on an offensive smell of garlic. The odor clung to their clothes and when the men tried to wash it off hands and faces, the smell became worse. Wives and neighbors complained. One night when Carroll Hochwalt went to a movie, the people around him changed their seats.

"I thought we really had it this time," Midge said regretfully.

"Try again," Charles urged.

A new year, a new decade, the twenties, arrived. The year 1920 is still remembered as the time prohibition became effective.

Charles' mother, Martha, died on January 26 at the age of seventy-five. Charles felt her death deeply. There had always been a closer tie between them than existed among any others in the family. Daisy and her husband Charles Heyde remained in the home place.

Charles began to work on a new project. Why should a nation of automobile owners have to put antifreeze in their radiators every winter, he wondered. Why should they put up with leaky radiators and rust? Why not cool the engine with air instead of water?

He built an experimental engine with a series of copper fins on the radiator. A fan at the back of the motor drew a cooling stream of air across the fins.

The need for a new kind of fan belt was met by Al Freedlander, a friend Kettering had made at the Engineers' Club. At the Dayton Rubber Company, Freedlander designed a V-shaped die cut belt which ran 47,000 miles as against

3000 for the next best belt. From this grew the V-belt industry, now an important part of the rubber industry.

In June of 1920 Charles developed still another interest. Dr. Arthur Morgan, who had started the Moraine Park School with the help of Charles and Colonel Deeds, had been elected to the Board of Trustees of Antioch College at nearby Yellow Springs, Ohio. The college had suffered serious financial reverses and was struggling for its life. Morgan suggested changing the curriculum to make the school co-operative, in which students spent half the time in classes and half the time working at jobs in industry.

The cooperative idea was one to which Kettering gave his full support, believing that the purpose of education is to prepare men and women to meet and solve problems. The cooperative method, he frequently pointed out in conversation and speeches, teaches a man while he is on the job the kind of problems he should solve. In the classroom he acquires the background for solving them.

Kettering became a trustee of Antioch in June and began a lifelong association with the school. He helped elect Morgan president of the school the following month.

Three college buildings that had been erected in 1853 needed modernizing, since they were without plumbing and central heating. To enable the college to borrow \$300,000 for the remodeling, Charles signed the note as security.

He never had time for golf, but starting in 1920 he played an intellectual golf game in his mind. Like other engineers he knew that a much more efficient source of power than the gasoline engine was the diesel. In the diesel a piston pushes air into a compression chamber—the first diesel had a compression ratio of 16 to 1—causing the air to heat to about

1000° Fahrenheit. Fuel oil is then injected into the cylinder. The gas formed by the fuel explodes immediately because of the heat, pushing the piston and turning the crankshaft. The amount of oil blown into the chamber regulates the speed.

Over a number of years the engine, invented by Rudolph Diesel in Germany in 1892, had gained slow acceptance. It was a slow engine, only 500 revolutions per minute, and awkward and heavy. At the time Charles began thinking about diesels, they were used on large ships and as stationary power plants, but no one had thought of using them for mobile power.

Now he began to think more seriously about diesels. "Why should they look and act like a steam engine?" he asked himself. "Why does the diesel have to be heavy?"

The more he studied the diesel the surer he became that it was heavy because Rudolph Diesel had made a heavy engine and it kept right on being that way. He read all the books about diesels. Every book he read said that it was the nature of a diesel to be heavy. He talked to other engineers.

"Why can't we have a lightweight diesel engine?" he asked them.

"It is impossible," the engineers told him. "You can never have a light diesel."

"I wonder," Charles said to himself. "I'm not so sure."

Women got the vote in 1920 and sallied out to elect Warren G. Harding as President over Governor James M. Cox, a Daytonian and friend of Charles.

Olive listened to the election results over a crystal radio set. As for Charles, he cared very little who won the election. Whoever sat in the White House couldn't help him solve the engine knock problem or figure out how to make a light diesel.

The night after election Charles, hearing the notes of Olive's piano coming from the music room, stopped in to listen. After a while he eased out of his chair and walked over to the piano. He rubbed his hand over the shiny finish.

"Olive," he asked, "if you set this piano out in the front yard for two weeks and let the sun shine on it and the rain and dew wet it, what would the neighbors think?"

"That it was time for the men in the white suits to take me away," Olive replied.

"And they'd be right. Now do you know that we put exactly the same kind of paint on our automobiles as is used on pianos?"

"Don't you ever think of anything except business, Charlie?" Olive asked, smiling.

"But there's so much to discover yet, Olive," he protested, "and I've only got one lifetime to find it all out."

Olive nodded understandingly.

The next day in Detroit he brought up the question of paint in a GM division managers' meeting. He told them about the piano paint.

"And another thing," he went on, shaking a bony forefinger at the men, "here at GM we can put an automobile together in exactly one minute. Do you know how long it takes to finish an automobile? It takes a little over two weeks for our Chevrolets and three weeks for the others. We have millions of dollars worth of cars sitting around drying and hundreds of customers sitting around waiting in dealer showrooms. Pretty soon we will have to roof over the entire state of Michigan for a drying shed."

The managers agreed something ought to be done. "Let's get a better paint that dries faster," Charles suggested.

A paint expert who had been invited to the meeting spoke

up. "How long do you think it should take to finish an automobile?"

"An hour," said Charles.

The meeting broke up. Boss Kettering had gone off his track, the managers told one another. Paint dries by oxidation. Everybody knows that. You can't hurry up nature.

On his next trip to New York, Charles spied a small tray in the window of a jeweler's store on Fifth Avenue. He went inside, asked to see the tray, held it close to his nearsighted eyes, put it down and said, "I'll take it. Where do you get these trays?"

The manager gave him the name of the manufacturer. Across town Charles taxied. From the manufacturer he got the name of the finisher. To a back-yard shop of a New Jersey painter he went next. He showed the man the tray.

"Interesting finish you have on this tray," he said. "What is it?"

"It's lacquer."

"Where do you get it?"

"I make it from cellulose."

"I'd like to buy a quart."

The man's eyes opened wide. "My gracious!" he gasped. "I never made a quart of it all at one time! What do you want it for?"

"I want to paint an automobile door."

The man shook his head. "You might as well save your money, mister. If you tried to paint an automobile door with this stuff, the paint would dry before you could get the brush from the can to the door."

Charles took the lacquer back to the lab. There by combining the fast drying lacquer and slow drying paint, Charles and some of his staff painted an automobile in about two hours.

He turned the problem over to chemists at E. I. du Pont de Nemours, Inc. The result some months later was Duco, a paint unaffected by heat, cold, and water, that dries in minutes.

The paint expert who had been present at the Detroit meeting of division managers stopped to see Charles one day before Duco was in general use. Charles picked up a color card from his desk and handed it to the caller.

"If you were refinishing your car, what color would you paint it?" he asked.

The man pointed out a color his wife liked. In a little while the two went to lunch after which they returned to the office. The paint expert looked out the window.

"I have to be going, but something has happened to my car. It's gone! I'm sure I parked it right out in front."

"That's your car standing out there," said Charles. "That is the color you chose, isn't it? I had your car refinished while we were at lunch."

On the morning of December 9, 1921, Charles bounded out of bed, ate a good breakfast, and hurried to the laboratory. In his office, he started going through the mail. He could hear the front door bang as the other staff men came to work. Suddenly he heard an excited yelp ringing through the halls. Sensing that something out of the ordinary had happened, he jumped up and hurried into the hall.

He bumped into a round-eyed Midge, who was coming after him.

"Boss!" Midge exclaimed, "Listen! Hurry! Come quick!"

Charles could hear the engine even before he joined Tab Boyd, Carroll Hochwalt and Charles Thomas in Midge's laboratory. The little engine was purring along like a happy kitten.

"Listen, Boss!" Tab shouted. "No knock!"

He speeded up the engine. The purr rose a step in tone, but it remained as smooth as cream.

"What do you have in here?" Charles asked, sticking his eyes close to the quartz window Midge had put in the cylinder wall.

"Carroll made a spoonful of tetraethyl lead from lead chloride and zinc ethyl," Midge answered.

"Tetraethyl lead. Does it smell?"

"Odorless."

"By gosh! What concentration?"

"Don't know. I put a teaspoonful in the tank and filled it."

"Reduce it down and keep reducing it until the knock starts."

"I'll let you know, Boss."

"What's the number of this test, Midge?" Charles asked.

"We tried exactly fourteen thousand, nine hundred and ninety-nine other compounds before this one," Midge told him.

Before the day was over, the boys found that one part of tetraethyl lead in 4000 parts of gasoline still gave knock-free performance.

"It's too soon to be sure," Charles cautioned. "Now let's try it in all kinds of engines on dynamometer blocks. If it works satisfactorily, we'll try it on the road."

Engines were not on the dynamometers very long before trouble developed. The lead chlorides formed in the combustion chamber dissolved the spark plugs.

The addition of carbontetrachloride caused the lead to burn to an oxide rather than a chloride. The oxide did not affect the spark plugs, but softened by engine heat, burned out the exhaust valves.

The next step up in the periodic table from chlorine is

bromine. Mixing ethylene dibromide with tetraethyl lead finally gave a chemical that eliminated knock and left no harmful deposits in the engine.

Just before the laboratory staff started to make road tests, all the men gathered in Kettering's office. "We've got to have a name for this stuff," he told them, holding a test tube of tetraethyl lead in his fingers. "What do you think of calling it Ethyl?"

They liked the name. "And what about giving it a distinctive color to make it stand out from other gasolines?" Midge asked.

"Splendid!"

"Remember the lucky thought you had the first day you put me on this fox hunt?" Midge went on.

Charles grinned. "The trailing arbutus," he said. "I remember. Sure! That's a grand idea! We'll color our Ethyl gasoline red."

12

Although Charles had not had what anyone would call an easy life, still in the end, everything he attempted had resulted in success. The successes had not been without difficulties, but every problem he attacked had at last yielded to his probing brain and fingers.

Now he was about to experience a failure.

Years of research, experiment, and testing the air-cooled engine satisfied him that the engine would prove satisfactory. GM experts, too, approved the engine and decided that rather than bring out a new car as they had first planned, they would use it in the 1923 Chevrolet.

Retooling began in 1922. The first new models appeared in dealer showrooms in October.

Suddenly after 3000 Chevrolets had been sold, production stopped. GM announced that the air-cooled Chevrolet was being withdrawn from the market and that all the cars now in possession of the public would be replaced.

The action dumfounded Charles. At once he went to Sloan, who had become president of GM shortly before, and asked for an explanation.

The reasons Sloan gave were complex. For one thing, he felt that the engine itself was not sufficiently developed for mass production. For another, the managers and chief engineers of the manufacturing divisions felt that the change was entirely too radical. Rather than compromise or try to salvage the air-cooled principle, Sloan had decided to scrap the entire engine.

Even years later, whenever Charles thought of the air-cooled engine fiasco, the sparks flew. He never did agree that the engine was not fully developed. And at the time his opinion of the managers and chief engineers fell exceedingly low.

Charles mulled the situation over in his mind. The air-cooled engine had cost the company millions of dollars. It should have been received with praise as a great engineering advance, he felt, instead of being scrapped. The longer he thought it over, the more discouraged he became. The radiator cap on every new Chevrolet on the streets angered and disheartened him. Finally he sent Sloan a letter asking to be relieved from his job as soon as possible.

Sloan, however, refused to accept his resignation. By the time Sloan's letter of refusal arrived on his desk, Charles was up to his ears in plans for introducing ethyl gasoline to the public.

He persuaded Willard Talbot, manager of the Refiners Oil Company, a Dayton company with seventy-five gasoline stations, to introduce ethyl gasoline in one station. Early on the morning of February 2, 1923, Daytonian Mike Redelle drove his Buick into the station and bought the first tankful of ethyl.

Soon Talbot began selling ethyl in all his stations in Dayton and Cincinnati.

In April, the General Motors Chemical Corporation was formed to market ethyl with Charles as president. As chief salesman he called on other gasoline men throughout the Midwest but found them hard to interest. One company president, indignant that anyone should suggest his gasoline needed improvement, offered to throw him out of his fourteenth-story window.

Charles developed a good sales presentation. He made

movies through the quartz window in the combustion chamber that showed in slow motion how knock occurred when the compressed fuel farthest from the spark plug exploded spontaneously before the flame reached it and how when ethyl was added, the fuel burned evenly. After he had shown the movie, he started an engine using untreated gasoline. When the knock began rattling the room, he dropped some ethyl fluid on the prospect's necktie and had him sit in front of the engine's intake valve. Magically the knock ceased.

Several weeks before the May 30, 1923, Indianapolis speedway race, Charles took two containers of ethyl fluid to the track and persuaded several of the racers to try it.

The favorite, Tommy Milton, set a new track record in the qualifying heat using ethyl. He also won the race. The ethyl permitted him to raise the compression ratio of his Stutz Bearcat from 6 to 1 to 7.5 to 1. Both the second- and third-place winners used ethyl. The resulting publicity boosted ethyl sales.

As sales increased, Charles faced a new problem. The entire world output of bromine, 800,000 pounds a year, was used by the photographic industry and a well-known headache remedy. It began to look as if the manufacturing of ethyl gasoline would need 800,000 pounds a month.

He hung a motto on his office wall—THE PRICE OF PROGRESS IS TROUBLE.

The Dow Chemical Company produced most of the bromine from brine wells in Michigan, and although Charles persuaded the company to sink sixteen new wells, they would produce only drops where he needed gallons. The Dow people told him he might get bromine in Zarzis in Tunisia. He made a trip to Africa to inspect the wells, but returned with no bromine. "Too far," he said.

Engineers told him that sea water contains bromine, one

pound in a little over seven tons of water. They added, "It is impossibly expensive to evaporate seven tons of water to get one pound of bromine."

But Charles decided to try to evaporate one pound of bromine out of seven tons of water. First he tried it at a spot near Ocean City, Maryland, but sand and surface water made problems.

"I'll go out into the ocean where we won't get sand and surface water," he decided.

He bought a Great Lakes steamer, christened her the *S. S. Ethyl*, fitted her out with bromine-extracting equipment and sailed into the Gulf Stream. After operating it for six hours, he and Midge, who was working with him, returned to shore with enough bromine to prove the method commercially profitable.

Back in Dayton another job was waiting for Charles. The Delco-Light Company with its farm-lighting outfit had created such a demand for electricity on farms that it could be satisfied only by the extension of power lines from the cities. Thus it put itself out of business.

But as Delco-Light sales were declining, the sales of another GM product, the home electric refrigerator, were increasing. Manufacturing of the refrigerator was now transferred from Detroit to the Delco-Light plant, and Charles became vice president of Frigidaire.

The refrigeration unit, consisting of a brine tank and a water-cooled compressor, had proved most unreliable.

Charles saw at once that he could substitute an air-cooled compressor for the water-cooled one, thus salvaging some of the work he had done on the ill-fated air-cooled engine. By adding a direct expansion coil, he eliminated the messy brine tank.

When the air-cooled compressor was approved on the Frigidaire, Charles hung a second motto on his wall:

NO ONE EVER WOULD HAVE CROSSED THE OCEAN
IF HE COULD HAVE GOT OFF THE SHIP IN THE STORM.

Because her husband rarely looked at a clock and did not understand that part of the twenty-four hours a day could be spent in other ways than working, Olive had had to turn to her own devices for companionship and entertainment. But now she began to have hopes of seeing a little more of Charles than usual because the tickets were bought and the trunks packed for a trip to Europe. Gene, of course, who at sixteen was still in high school at Moraine Park, had to be left behind.

On a hot September afternoon in 1924 Charles was pitching a few last minute things into his suitcase when the front doorbell rang.

"Whoever it is," Olive called after him, "remember we are leaving for New York tomorrow."

Charles swung open the door. Outside stood George B. Smith and Claude Burnett, a director of Winters National Bank.

"I know how busy you are, Mr. Kettering," George began, "but this is a most urgent matter."

Charles took the men to a cool apartment over the garage. Quickly Burnett explained the urgent matter. Winters Bank, oldest in the city, was about to fail. Burnett felt that only a man of Kettering's reputation and wealth could prevent the impending collapse of the bank with all the hardship such a failure would bring to the community.

"All I know about banks," Charles said when Burnett had finished, "is that when a man hasn't any money and needs it, he can't get a loan from a bank, but when he has plenty of

BOSS KET

money and doesn't need it, then the bank wants to lend h more."

Burnett smiled weakly.

"I don't know anything about banking," Charles continued.

"Mr. Kettering," Burnett pleaded, "you are the only man in the city who can save the bank. Will you do it?"

Charles looked at his financial manager. "Can we handle it, George?"

"If the figures Mr. Burnett presented to me are accurate, we can handle it."

Charles got to his feet. "Very well, then, you go ahead and get an option on the Winters stock. As you know, I am leaving for Europe tomorrow. When I return, I will do all I can to put the bank back on its feet."

He and Olive left for New York and Europe the following day. While Olive saw the sights, Charles prowled around diesel factories, but they managed to do a few of the usual tourist jaunts together.

As soon as they came home, Charles met with the bank personnel and reorganized it completely. He himself became chairman of the board.

"Now I don't know much about business or banking because I have been a mechanic all my life," he told the bank officers, "but I do know that every bank in the country receives and pays out money. The difference between one bank and another is the kind of service it gives and the courtesy with which it is given."

Under his chairmanship the bank increased its capital funds from one and a half million dollars to fourteen million dollars and its total resources from ten million to two hundred and twenty-five million dollars.

While Charles and Olive were in Europe, the sales of

ethyl gasoline had soared. It began to look as though ethyl would prove a financial success, even though the years of search for the chemical had put ethyl four million dollars in the red. And then the roof fell in.

Everyone connected with the manufacture of tetraethyl lead knew that lead poisoning was a serious danger. Workers in the plants received constant warnings to follow safety practices. On October 26 an accident at the Jersey Standard Bayway plant poisoned dozens of workers and killed five men. Manufacture of ethyl was stopped at once while medical and chemical investigators rushed to the scene.

News of the deaths spread through the country like lightning. Everywhere people who had used ethyl gasoline in their automobiles became frightened. Further hysteria was created when the fact was published that deaths from lead poisoning had occurred earlier at Dayton and at the du Pont Deepwater plant. Sensational stories in the press had everyone believing that gasoline containing ethyl accidentally dropped on the hands lowered the blood pressure, causing unconsciousness and death before the victim could wash his hands. Dr. Yandell Henderson, a Yale University expert, declared that breathing exhaust fumes from ethyl gasoline attacked the brain and nerves, causing delirium, paralysis, and death. "Loony gas," as the papers labeled it, became notorious overnight.

Sale of ethyl was banned in New York on October 30. On November 3 Standard Oil Co. of New Jersey withdrew ethyl from the market.

Midge made a trip to New York during the investigations. Although he demonstrated that Henderson's statements were false by washing his hands in tetraethyl lead in the presence of reporters, the wild stories continued. It was useless for him to point out that the fatalities had been caused by heed-

lessness of the workers and that ethyl was harmless when properly handled.

During the height of the hysteria, the announcement by Henderson of the results of further tests created still more uproar. The shaved stomachs of five goats had been painted with ethyl gasoline. The five goats died.

In Dayton a reporter asked Charles, "Doesn't that prove that your gas is poisonous, Mr. Kettering?"

"It proves only one thing," he snapped, "somebody has five dead goats!" He went on to explain that for all anybody knew, goats painted with gasoline without ethyl might die, too.

Because of the continued hullabaloo the Ethyl Corporation suspended the sale of ethyl fluid on May 5, 1925, and asked Surgeon General Cummings of the United States Public Health Service to investigate the health hazard. The Bureau of Mines also conducted tests, as did Columbia University. Until the tests were completed, the Ethyl Corporation remained out of business.

Other projects sprang up, meanwhile, in every corner of the laboratory. Engineers from Detroit who came to work under Charles' direction became frequent house guests at Ridgeleigh Terrace. Olive delighted in entertaining them at dinner and playing the organ afterward in the music room.

Gene, now at seventeen almost a young man, greatly enjoyed getting to know the automobile executives who came to visit.

His father's hope for Gene was that he might grow up to have vision, courage, and imagination. Whenever he could spare the time, which was rarely, he took the boy on hikes to woods and streams. He bought mechanical gifts which were to be taken apart and put together again as well

as to be played with. Gene liked tinkering, especially with automobiles, much better than he liked studying in school. But Charles did not make things easy for Gene as many wealthy fathers might have done.

"Men who came up the hard way and make things easy for their sons deny them the discipline of struggle that worked so well in their own cases," he frequently pointed out.

To Gene he explained his actions by telling the story of the amateur naturalist who raised butterflies as a hobby. Watching a butterfly struggling to get out of the cocoon one day, he split the cocoon so that the butterfly could crawl out without struggling. Unfortunately, the butterfly was never able to use its wings.

Gene planned to study engineering at Cornell when he finished high school. Getting to know some of the great engineers of the world on a friendly plane was a challenging experience for the boy.

With passing time the staff at the laboratory grew and grew. Realizing that his desire to remain in Dayton was making a hardship on the many men who had to leave their homes to work for him, Charles decided to move the laboratory to Detroit. The change occurred in 1925.

Since both Charles and Olive had grown to love their Dayton home, they resolved to keep it as their permanent headquarters to which they some day hoped to return. In Detroit they lived in a suite in the Book-Cadillac Hotel. When his research on paint finishes required tests in Florida, he and Olive lived at the Surf Club in Miami.

Meanwhile Surgeon General Cummings completed his tests on ethyl gasoline. After almost a year he released his report. "There are no good grounds," he said in part, "for prohibiting the sale of ethyl."

ETHYL IS BACK signs appeared in filling stations in June, 1926. The year off the market had put the Ethyl Corporation another three million dollars in the red.

The discovery of ethyl fluid was one of the great advances in petroleum history. The Liberty engine of World War I developed 400 horsepower. The Allison engine of World War II, using ethyl gasoline, although it was only 4 per cent bigger, developed 1500 horsepower.

The Cadillac engine of pre-ethyl days developed 77 horsepower and at fifty miles per hour traveled seven miles on a gallon of gasoline. Today's much smaller engine develops 325 horsepower and at the same speed goes more than twice as far on one gallon of gasoline.

Today, because of high octane gasoline and the high compression engines ethyl made possible, two gallons of gasoline do the work of three formerly. At thirty cents per gallon every driver saves three dollars whenever he buys a twenty-gallon tankful of gasoline. Since drivers in the United States use about thirty billion gallons yearly, the saving is about eight million dollars annually.

One morning over their breakfast eggs, Charles said to Olive, "I think we're going to have to get a yacht."

"A yacht?" Olive's eyebrows went up. "Now when would you ever have time to go yachting, dear?"

Charles grinned. "Yachts are powered by diesel engines. If we had one, you and Gene, when he is not in school, could enjoy the cruises, and I could learn more about the engines."

"I might have known you weren't about to turn into a playboy." His wife smiled.

He bought the yacht at Bay City, Michigan, naming her the *Olive K*. She was powered by two ponderous diesels that rattled, snorted, and coughed constantly.

The shaking and unsteady power produced by the engines, Charles soon discovered, was due to the method of injecting the fuel into the cylinders. The fuel was forced through long lines by a pump located at some distance from the cylinders. Because the pressure was not constant, the fuel was injected unevenly, causing the engines to spurt ahead or slow down as the pressure rose and fell. Further vibration of the ship was caused by the failure of the two engines to synchronize.

He decided to sell the yacht and have another *Olive K* built to his own specifications. He asked the Winton people, who built the new engines, to fit an individual fuel injector on each cylinder, eliminating the central fuel pump. The new injectors fed the fuel steadily and under higher pressure than was possible with the old method and the ship traveled faster and smoother than any other diesel-powered ship had ever run.

The new *Olive K* was 170 feet in length, large enough for ocean travel and luxuriously furnished. For her maiden voyage, Charles and Olive invited a number of guests. As the ship pulled away from the dock, they assembled in the lounge, expecting that Charles would want to show them the ship. Finding no host, one of the men asked, "Where do you suppose the boss is?"

Olive laughed. "Probably down in the engine room."

Sure enough, the guest found him with fuel oil on his yachting cap down on his knees beside one of the shiny diesels. "Don't you want to show off the *Olive K*?" he asked. "Don't you hire somebody to run these engines?"

Charles scrambled to his feet. "What I'd rather do," he said, grinning, "is hire somebody to play the part of the yacht owner."

Using the experience he gained down in the engine room on numerous cruises, Charles designed an improved fuel injector with tiny pistons that had to be accurate to within one-quarter of a tenth of a thousandth of an inch to prevent leaks under the pressure of 20,000 pounds per square inch. The pump squirted fuel into the cylinder at the rate of 780 miles per hour.

When the new injector was attached to the one-cylinder laboratory engine Charles had built, the piston broke down. He said to the lab boys:

"Write down what happened today and put in a new piston tomorrow. And when that one breaks, put in another."

"Isn't this a tedious kind of way to get a good piston?" one of the researchers asked. "Why don't we just design the right kind of piston?"

"You have to let the engine choose the piston it wants," Charles told him. "You have to make pistons and engines the way they want to be made, not the way you think they should be made. There's a motto in my office I wish you would come and look at every now and then. It says LET THE PROBLEM BE THE BOSS."

After trying out several hundred pistons, the engine finally found one it liked. It was quite different from the kind of pistons the textbook said diesels needed.

To increase the slow speed of the diesel, Charles suggested changing it from a 4-cycle engine to a 2-cycle one, firing on every stroke of the piston instead of every other stroke. By this change the power could be doubled without increasing the weight. For testing, two 2-cycles were built, one at the laboratory and one at the Winton Company.

When the GM laboratory moved from Dayton to Detroit,

it was established partly in the downtown GM building and partly in the old Cadillac building where Charles had met and worked for Henry Leland fifteen years before. Now the laboratory was moved into its own new eleven-story building. The staff was increased until Charles had 250 skilled mechanics, 150 technical researchers, and 100 clerks and students working under him.

Part of his time he spent on advanced engineering research in such problems as the diesel. Part of his time he devoted to acting as consulting engineer on specific problems of the GM manufacturing divisions. It was in this latter role that he gained the reputation of a man who could outthink a roomful of experts in any field and slice a bluffer or a sloppy thinker to pieces with a well-turned sentence.

The old impatience for following formulas he had developed in his chemistry laboratory at Ohio State never left him. When he learned that the automobile divisions were having trouble with breaking steel springs, he sent for the spring manufacturers who supplied them.

"I want you to send us springs that won't break," he told them.

"We can't," they answered. "Steel has a fatigue point, as do all metals. When the point is reached, the steel breaks."

"How do you know that?" Charles demanded.

"A formula has been worked out by experts. The formula says that steel will bend so many times."

"I would like to test that," he told them.

He had each manufacturer send him ten springs, each a flat piece of steel 18 inches long, $\frac{1}{4}$ inch thick. He put them into a bending machine and, sure enough, each spring broke shortly after 2000 flexings. At the same time similar tests at the ten spring factories showed the same results.

"You see," said the spring manufacturers at another meet-

ing, "you can't expect us to supply you with springs that will run any longer than the formula says."

Charles rubbed a thumb along his jaw line. "Suppose I bang up a piece of steel until it is roughened all over. How many times will it flex then?"

The experts talked it over. "We have no formula for rough steel," they said finally, "but it won't last long, we're sure of that."

"Make me some more samples," Charles suggested. "Put an identifying mark on them so you will know them."

He gave the second batch of springs a shot-blasting treatment, bombarding each piece of steel with thousands of tiny steel balls until it was roughened. Then he returned the samples to the manufacturers for testing.

The springs bent two million times without breaking. After that the manufacturers stopped testing.

"You see?" Charles grinned. "It's a good thing those springs didn't know about your formula."

Drivers of GM trucks complained that since their trucks traveled about a thousand miles a day, having to change engine oil every thousand miles cost too much time and money.

To help the truckers Charles fiddled around until he developed detergents that would clean the oil, allowing it to run at least a hundred thousand miles. Then he invited the oil companies to send representatives to see a demonstration.

In his laboratory Charles showed the men two GM engines. One stood on the dynamometer silent and cold; the other putted merrily along.

"This engine filled with your old oil broke down shortly after a thousand miles. This one"—he pointed to the other engine with his long forefinger—"using our new oil is still running after a hundred thousand miles."

Naturally the claim disturbed the oil men. "Hmmmph!" exclaimed one. "There isn't anything wrong with our oil. It's your GM engine that isn't any good."

Charles whirled and sized up the fellow. "I believe I would like to hire you," he said. "How much money do you earn?"

"Ten thousand a year," answered the man.

"I will pay you twenty-five thousand dollars," Charles said. "Now here is a drawing board and paper. I want you to sit down and design me an engine that is good."

The man blinked. "I couldn't do that," he said. "I don't know anything about engines."

"I knew that," Charles said, "but I wanted to hear it from you."

He turned to the others. "These two engines are as alike as mass production can make them. The only difference is the oil, and you will have to admit that it is pretty spectacular."

Oil companies began studying the detergent problem as a result of the demonstration. Today the oil you put in your automobile engine contains a detergent.

When a worker in the laboratory was found in a mistake by Kettering, the worker rarely made the same mistake again. One day Charles turned some samples of a new kind of steel over to a machine-shop foreman, saying: "Drill out some of these and send the drillings to the metallurgical department for testing."

A few days later Charles looked him up. "Did you send those steel samples over to the metallurgical department?" he asked.

"No," the foreman answered. "I couldn't drill the steel at all. It was so hard that it turned the point of my drill right over."

"Did you try a diamond-pointed drill on it?" asked Charles.

"No."

"Let's try it right now."

The foreman got the samples and the diamond-pointed drill. Charles put a neat hole through the steel. He laid down the drill and looked piercingly at the man.

"You told me something that was not so," he said. "You told me the steel was so hard you could not drill it. That is not so. It was your drill that was too soft."

Frequently GM Research hired young engineers just out of college. Often they came fresh from school knowing a great deal more about everything than the experienced men at the laboratory knew. Once a new employee tried to impress Charles with how much knowledge he had stored in his mind.

"We don't hire a man for his knowledge," Charles told him. "For seventy-five dollars we can buy an encyclopedia that has more knowledge than any man could get in a lifetime, and we don't have to board it!"

"I suppose you want a man with intelligence," the young man countered.

"Not intelligence but intelligent ignorance. When we want a man to work on a problem we ask him if he knows anything about it. If he truthfully can answer he knows nothing, we hire him. If he thinks he knows something, he will get in here and first thing you know he will be telling all the others what he knows and after a while they all will know that the problem can't be solved."

Charles put just such a fellow to work on the fundamentals of lubrication and friction. One day as he entered his laboratory, the young man asked, "Must I spend my whole life rubbing two little blocks of metal together? Don't you

think this job is a little beneath the dignity of a man with my education?"

"Oh," said Charles, "I didn't know you had one."

"It wouldn't be so bad," the youth continued, "if all this wasn't already solved and in the books."

"Young man," Charles said, "I'll give you a substantial cash award if you can find the solution to this problem in a book and bring it to me."

Two months later he met the young man again. "Sir," he said, "there is absolutely nothing in the books about this. In school they told me everything was known about bearings and lubrication. I guess this is a more important job than I thought."

Another time Charles was very easy on a fresh young employee. He saw the young man in the hall, a stranger to him. "How are you getting along?" he asked.

"I'm not getting along at all," the young man told him.

"What's the trouble?"

"Oh, it's these dumb heads of departments around here. Where do you suppose they dig up the stupid people who run this place?"

"Oh, we scrape them up from somewhere." Charles grinned and went on down the hall.

He was still grinning when he entered his office. On top of the stack of morning's mail was a letter from Ohio State University. He glanced down at the signature. The letter was from George W. Rightmire, president.

"Hmmm," said Charles and began to read.

He told Olive about it at dinner that night. "You know I graduated from college twenty-five years ago this June," he said, "and they've invited me back. They're going to give me an award of some sort and a Doctor of Engineering degree and I'm to make the commencement address."

"That's wonderful." Olive smiled. "It doesn't really seem like twenty-five years since I came to watch you graduate. Remember, you couldn't afford to take us all to the Senior Breakfast?"

His long face saddened. "Poor mother and dad! I wish they could be here now. I remember how we all had breakfast at Mrs. Young's. Say, let's look her up when we go to Columbus, what do you say?"

"Do you think she is still there?"

"Sure. This time let's take *her* to breakfast."

"She'll be mighty proud of you, Charlie. So will everybody. You'll be the local boy makes good."

"Aw, I'm not so much, Olive."

"Now, Charlie!" Olive smiled fondly.

It was the fifty-second commencement of Ohio State University. Charles was given the degree of Doctor of Engineering and the Sullivan Award.

In the commencement address Charles told the graduates about the young lad he had met in the hall.

"You are going to find out," he told them, "that your first boss is not going to be so good. But if you stay with him long enough, you will find that he is going to improve."


He pointed out that everyone has problems to solve in his life. "But the only hard problem you will ever strike is one that you don't know how to solve." He told the story about the man with the soft drill. "Every time you strike a hard job, it is because you are using a soft drill. You can't change the job, but you can change the drill."

Charles told the graduates, their parents, and guests, that on the trip through life, everybody is a servant to somebody or something. He concluded:

"When you pack your bag for this eventful journey, if you pack egotism and selfishness in the bottom of your bag

and lay on top your uniform of service to humanity, when you come to the end of the trip, your passport will not have to be inspected. They will pass you right on through the line.”

13

 Life in 1929 in the United States looked rosy. Women wore their belts around their hips and their skirts barely covering their knees. They went to see Ronald Colman's first talking picture. Men in starched collars and hard straw hats hurried home from their jobs to listen to Amos 'n' Andy on the radio right after Lowell Thomas.

The stock market rose steadily during 1929, right up to September 3. On that day stocks reached the highest point in Wall Street history. Kettering's hundreds of thousands of shares of stock in General Motors rose to 72¾. On September 4 stocks began to dip. On October 29 came the big crash.

Stocks fell swiftly. They declined steadily until November 13. By that day stock owners had lost thirty billion dollars.

On November 13 GM stock dropped from 72¾ to 36. It was to decline to 7½ during the worst of the depression. Such losses bankrupted men who owned stock on margin. For a time during the weeks after the October 29 crash hotel clerks wondered whenever a well-dressed man rented a room whether he wanted it for sleeping or jumping out of the window.

"What would you do," someone asked Charles, "if you lost all your money?"

"Just what I did before, when I didn't have any," he answered. "I would make something people need and would

pay money for. I'm not afraid of losing my money. A man's assets are in his brains, not his money."

In January, 1930, he decided to take the *Olive K* on her first major winter cruise, sailing to the Galapagos Islands. Guests were Dr. Roy McClure, chief surgeon of the Henry Ford hospital in Detroit; Gar Wood, Detroit manufacturer and speed-boat racer; John L. Pratt, a GM vice president; Julius F. Stone, a Columbus manufacturer; Robert Lamphier, of the Sangamo Electric Company, and Bill Chryst.

Another prospective guest was Gene Kettering, who was finishing the first semester of his senior year at Cornell. Missing seven weeks of classes would mean loss of credit, consequently making it impossible for him to graduate. At first Charles said that Gene could not go. But John Pratt's argument that Gene would learn more from associating with the kind of men who would be on board than from school swayed Charles. In the end Gene went.

Although no women ever went on any of the long cruises of the yacht, Olive and Virginia Weiffenbach, a Dayton classmate of Gene's at Moraine Park School, sailed from New York as far as Havana, with a stopover at Miami.

It was on this cruise that Gene and Virginia planned an April wedding.

Charles became very fond of the prospective member of the family. Tall, slim, blond with jolly blue eyes, she had a vivacious spirit that complemented Gene's quiet, serious nature.

Both Charles and Olive gave their blessing to the match.

At home, on cruises or in Detroit, Charles kept in frequent touch with Antioch College. Work was completed in 1930 for the Science Building, a gift from him. Inside the

main entrance hangs his portrait and underneath it a typical Kettering remark: THIS IS A PLACE TO WORK IN, NOT A MONUMENT TO ANYBODY.

On the top floor of the science building was a special laboratory financed by him, set up to find the answer to a question he had first asked long ago when a barefooted boy, he tramped along behind the corn planter.

"You plant a grain of corn," he said, "and in ninety days or so you get a corn stalk weighing two thousand times as much as the original seed. You can eat the corn and burn the stalk and get light and heat. Only five per cent remains in ash. You can take that ash, put it into the ground, and plant another grain of corn.

"The ninety-five per cent was made by the sun, from air and water. That grain of corn knows a trick that no scientist knows—how to take the sun's energy and form organic compounds from inorganic."

To find the trick, he now established the laboratory known as the Kettering Foundation for the Study of Chlorophyll and Photosynthesis. Charles made fun of the long, fancy Greek words in the name. "We are simply trying to find out why the grass is green," he explained. "We don't know any more about it in Greek than we do in English."

In the beginning the staff, in addition to Charles, consisted of two physicists, a biologist, and a chemist. "Be sure to get married and have lots of children," he told the staff. "This is a two-or-three-generation job."

An engineer once said he could see no practical value in finding out why the grass is green. "When we know that," Charles told him, "we can run our automobiles directly on sunshine."

"Impossible!"

Research on the diesel engine progressed steadily in the GM laboratories during 1931. One day Charles saw Alfred Sloan in the hall.

"I think we have got to the point where we ought to put the diesel in a locomotive," he told Sloan. "I want you to okay a program of five hundred thousand dollars to develop a diesel locomotive."

"Well, Ket," Sloan said, "I think we ought to do that very thing, but you can't do it for that money."

"I know that," said Charles, "but when we've spent that much, I know you'll have to finish the rest."

Trusting Charles' cheerful picture of the future of the diesel, President Sloan recommended that GM buy the Winton Engine Company, makers of the old European-style 4-cycle diesels for maritime uses and gasoline engines for rail cars. At about the same time officials of Electro-Motive, a Cleveland plant which designed and sold the rail cars for which Winton made the engines, realized that if they were to survive the depression, they would have to find an engine that would deliver more power cheaper than their gasoline engines. They began to inquire about diesels.

At this point GM bought Electro-Motive with the idea of manufacturing railroad cars using their diesels.

One day in August, 1932, Charles was called to Sloan's office. There he met the chairman of the board of one of the nation's largest railroads, who showed Charles a fat sheaf of impressively bound papers.

"This report will tell you," the chairman said, "why our engineers have decided that the diesel engine will never fit into the work of the railroads." He gave Charles an I-guess-that-will-settle-you look.

Charles grinned. "Without even reading your report, I

will sign it and agree completely. But the trouble is your engineers are talking about the heavy, slow, 4-cycle engines that push tugboats around in harbors. But the new lightweight 2-cycle diesel we have developed here is an entirely different matter. It is strong enough to pull a railroad right out of bankruptcy."

At the Century of Progress World's Fair in Chicago the following spring, Charles showed his two experimental diesels, providing power for the Chevrolet exhibit. Each was an 8-cylinder 2-cycle 600 hp. engine $\frac{1}{3}$ the weight and $\frac{1}{4}$ the size of the conventional diesel of the day.

Among the thousands who viewed the engines was one man who looked with more than idle interest, Ralph Budd, president of the Burlington Road. His railroad, like all the rail carriers, had been hard hit by the depression, truck competition, bus and air travel, and by the inefficiency and high cost of the steam locomotive.

Budd had decided to do something most unusual to try to stave off bankruptcy. At Electro-Motive he was having a three-car train built, a lightweight, streamlined, stainless steel exhibition train called the Pioneer Zephyr. To power it he needed a fast, lightweight inexpensive kind of power. Kettering's diesel struck him as being the answer.

He went to see Charles in Detroit. "Will you build me one of your diesels for my new train?"

Charles pointed out that while the engines at the Fair were operating very satisfactorily, they were stationary and under constant care of mechanics. "I don't know whether one would hold up on a train," he added.

Budd wanted to take the risk and so did Charles. His new diesel was ready the following February. The Pioneer Zephyr made a dramatic run from Denver to Chicago on

May 26, 1934, to open the second year of the Fair. The run of 1015 miles was the longest nonstop run in railroad history, and was made in thirteen hours, five minutes, as against the previous best time of twenty-six hours. Cost of the run was seventeen and a half dollars for fuel oil.

Delighted with the Zephyr success, GM began to make diesels to haul full-length conventional passenger and freight trains. The Electro-Motive plant moved to LaGrange, Illinois, near the railroad center of Chicago. Since the move the plant has grown constantly. Charles frequently remarked, "It's too bad when we built that plant that we didn't think to put the back end on wheels."

Gene and Virginia, with their family now increased by daughters Susan and Jane, moved along with the factory, making their home in Hinsdale, Illinois. Gene finally became chief engineer with Electro-Motive.

As always with a new product the critics and skeptics gathered around. Charles, of course, was used to them. Now, instead of Henry Ford's telling him, "Young man, I am not going to put your self-starter on my automobile," it was the president of a railroad telling him the diesel would never supplant the Iron Horse.

Charles recalled the electrical engineer who had told him long ago, "Young man, you have violated every principle of electrical engineering," when another engineer button-holed him in front of a piston exhibit at a convention. He had been looking in a glass case at two pistons sawed in half. One was the conventional piston the diesel textbooks said to use; the other was the one the engine had chosen in Kettering's laboratory.

"I don't know how ever on earth you designed a cockeyed thing like that," the engineer said, pointing to the second piston.

"It ran one and a half million miles without needing new rings," Charles pointed out.

"Now this other piston," the engineer continued, "it's a good one. It's the kind you ought to use."

"But it had to have new rings after fifty thousand miles."

"I still say it is better."

"How do you know?"

"I ought to know. I am a combustion engineer."

"Quite so. But were you ever a piston in a diesel engine?" Charles asked drily.

Shortly after Electro-Motive had begun delivering diesels to the railroads, a spokesman for the steam engine industry made a very damaging talk before an engineering society, proving by charts and logic that the diesel engine could not handle heavy railroad work.

Fearful of the influence of the talk, the manager of Electro-Motive asked Charles to make a statement refuting the steam engine spokesman.

Charles drawled, "The very best thing that could happen to us is to have our competitors think we are unable to do the job. Let's help them keep on thinking that. That way we won't be bothered by them while we are working out the bugs in our diesel."

Sure enough, by the time the steam engine people began to take the diesel seriously, it was already too late. In fifteen years the diesel made obsolete the steam engine, which had dominated the railroad industry for 100 years.

Today more than 98 per cent of all railroads are diesel powered.

During the Thirties Charles took the *Olive K* on several long cruises, but now that there was no more pioneering to


do in the engine room, he used her less and less and finally sold her to the Sandy Hook Pilots' Association.

In 1939 his oldest brother, David, who had never married, died. As he stood by David's grave with Adam, Emma, and Daisy, Charles wondered uneasily who would be the next to lie beside Jacob and Martha.

The following year, George B. Smith, who had handled his financial affairs for so long, died. Charles then turned his estate over to the trust department of Winters Bank.

"If I were dead," he told the men, "you'd be the executors of my estate. Now why don't you start execing now and let me be the living remains. You run the house, you run the automobile, you buy the airplanes and all that kind of stuff. The only thing I want to do is stay with the screwdriver and pliers."

14

 It always happens whenever a war threatens the country that thousands of men and women and sometimes even children spend countless hours inventing devices for helping win the war. During World War I the Naval Consulting Board in Washington received 110,000 suggestions from inventors. Although about ninety-eight per cent of the inventions were amateurish or unusable, careful examination of each had to be made. Out of the suggestions came two that did help to win the war—an improved airplane bomb and a rapid-fire rifle.

As soon as Hitler's soldiers began rolling into Denmark and Norway in 1940, once again suggestions, inquiries, and models of new inventions began to pour into Washington. To handle the large stacks of letters, President Franklin D. Roosevelt established the National Inventors Council, composed of twenty outstanding scientists and inventors, serving without pay, to read and evaluate every suggested invention. Charles was appointed president.

All during the war the Council published information about the needs of the military and screened ideas as they came in. Between August, 1940, and June, 1946, the Council received 208,975 suggested inventions. Of these 106 survived further tests and were put into use, two of the best known being the mine detector and the mercury-cell battery.

When Pearl Harbor was followed by the entry of the

United States into World War II, General Motors, as did other manufacturers, switched to production of war materials. Electro-Motive kept busy turning out Kettering's diesels for submarines and subchasers.

His experience with the naval experts who designed the subchasers strengthened Charles' old belief that experts don't know everything. He went up to Bay City, Michigan, to see the launching of the first subchaser powered by his diesel. Early on the morning of the launching, he strolled down to the river bank to take a look at the ship. He found an old tugboat captain whom he knew also looking the ship over.

Charles squinted up at the propellers. "Joe, those things look too long."

"They always make them too big, Boss," Joe answered.

"Well, if you were changing them, Joe, what would you do?"

"I'd cut off about seven inches."

Charles nodded and strolled off to find the fellow in charge. "We have recalculated the propellers," he told him, "and find that you have made an error."

The naval architect paled a little and ran for the telephone. Shortly Charles received a call from headquarters.

"We have been checking here," the head man said, "there is no one up there who can calculate propellers."

"You'd be surprised," said Charles and hung up.

Sometime later a second call came. "How much do you think the propellers are off?" asked the same man, a little less snappish now.

"About seven inches," Charles told him.

"Well, there was an error in the calculations, but it isn't seven inches," the expert told him. "It is only six and a half

inches. What worries us down here is how you found this out. Can someone meet me tonight at the airport?"

Charles sent a car for the naval expert, who, as soon as he arrived, hustled around to Kettering's room. "I would certainly like to know how you found that out," the expert repeated.

Charles grinned and told him about Joe. "This fellow has been looking at propellers all his life. They just looked too big to him. It's perfectly amazing how good fellows who have had experience are sometimes."

When the NBC Symphony was about to go off the air in 1943, GM decided to sponsor the program to enable it to continue. During each intermission Charles made a short talk from wherever he happened to be on whatever subject appealed to him. He made the brief talks every Sunday afternoon from September 12, 1943, to June 18, 1944.

Charles lost a good friend late in 1944. Tom Midgley, who had come to work for him back in the Delco days, died on November 2.

Tom, of course, had been the chief researcher in the engine-knock fox hunt. Also under Kettering's direction he had discovered the refrigerant freon used in all electrical refrigerators. Tom's education had been as a mechanical engineer. In the beginning he had wanted Charles to put a chemical expert on the knock problem. "An expert," Charles told him, "is a man who will tell you what can't be done." Midge stuck to the job and when he died at fifty-three he was president of the American Chemical Society.

Another good friend, Alfred P. Sloan, Jr., who had retired as GM president to become chairman of the board, was making plans to establish a center for cancer research

in New York City to be connected with Memorial Hospital for Cancer and Allied Diseases. He wanted Charles to be associated with him in the venture more because of his ability in laying out methods and directions of research than for any financial help he could give.

Charles did agree to join, having had the cancer problem brought home to him deeply when his older sister, Emma June Cullen, died of the disease on December 10, 1944.

Announcement of the establishment of the Sloan Kettering Institute for Cancer Research was made on August 7, 1945. Accompanying the news was word of Sloan's gift of four million dollars to erect and staff a building. Unfortunately the news of the largest single gift for cancer research ever made was almost lost in the press because news of the explosion of the world's first atom bomb broke the same day.

"Over the years Mr. Sloan and I have worked on so many apparently hopeless problems," Charles said. "If we can turn up something new in this field, it will be ample reward."

Shortly after the new year of 1946 began, Charles and Olive planned their annual jaunt to Florida. Because he had a few pressing jobs to attend to in Detroit, Olive went on down to the Surf Club where Charles planned to join her shortly.

Then he received news that Olive had become quite ill. He arranged at once for her to be brought to Henry Ford Hospital in Detroit under the care of their friend Dr. Roy McClure.

Charles was worried. Olive had never been sick before. Things just weren't right with her lying in bed in a hospital. But when McClure suggested after careful examination that he thought she needed surgery, both Olive and Charles agreed that if surgery was what the doctor ordered, surgery it would be.

After the operation, McClure took Charles into his office.

"How is she?" Charles wanted to know. "Is she going to be all right?"

McClure looked grave. "I'm sorry," he told him, "but we found something I had not suspected, cancer of the pancreas."

Charles stared at him as if stunned as the dread word sank into his brain. "How—how bad?"

"Very bad, Ket, very bad. We relieved the situation temporarily; for a while she will be a little better. But we couldn't get it all."

Charles slumped dejectedly in his chair. "Poor little Olive," he said. "How long, Roy?"

"About three months."

Three months. April. Spring again. "I don't want her to know. I don't want her to suffer."

He dropped every activity that he could so that he might spend every possible moment with Olive.

She died on April 30. Charles brought her back to Woodland Cemetery in Dayton. Poor Olive! She had wanted more than anything else to come back with Charles to live at Ridgeleigh Terrace. He had promised her that they would come next year when he was seventy and retired from his job. But she could not wait.

His answer to grief and loneliness was work, work, work. On his return to Detroit after the funeral he spent more and more hours on his projects at the laboratory. Why should he go home to that suite in the Book-Cadillac? There was no Olive waiting.

Charles was busy now working with oil men, trying to get them to change the nature of gasoline so that automobile makers could bring out high compression engines.

The discovery of ethyl had meant that the compression

ratio could be raised from 4 to 1 to 7 to 1. But beyond that, Charles told the oil men: "Your gasoline will have to be changed. When Mother Nature formed petroleum in the earth, she did not have the gasoline engine in mind. It is foolish to expect that the best arrangement of molecules in gasoline will be found in crude oil."

"A cockeyed idea," the petroleum men said. "You can't raise compression ratios any higher. The engine will be too rough. You will have ignition trouble."

"Guess I'll have to show them," Charles told himself.

By testing various fuels in engines Charles had learned that triptane (2,2,3-trimethyl butane) is a fuel with an exceptionally high knock rating. An experimental plant was built in Detroit to produce triptane and other fuels for testing.

When the war ended Charles had enough triptane on hand to test engines of exceptionally high compression ratio, even going as high as 15 to 1 without knock.

He had found in testing a single-cylinder engine that efficiency of the engine increased as the compression ratio was raised up to 12.5 to 1. Heat loss in ratios of 14 and 15 to 1 caused a decrease in efficiency.

He next built a high compression 6-cylinder engine with a ratio of 12 to 5. It was mounted in a standard 1946 Chevrolet body with hydra-matic transmission.

In road tests a standard engine of the same horsepower was used for comparison. Performance of the two engines was almost identical, but the real difference showed in fuel economy.

At constant speed on level road the high compression engine gave from 35 to 40 per cent better economy than the standard engine. At 40 mph the standard car gave 18.5 mpg. The 12.5 ratio engine gave 26.5 mpg, or a saving of

about 40 per cent. At 60 mph the saving was 35 per cent.

On cross-country driving the average gain was about 33 per cent. In city traffic driving the gain was over 40 per cent.

The engine roughness predicted by the petroleum men was eliminated by proper design of the engine. A slight modification of the ignition coil winding and core material enabled the conventional 6 volt ignition to be used.

His experiments proved that if the petroleum industry in changing its refining methods would raise the octane rating of gasoline to 100, the automotive industry could increase the compression ratio to 12.5 to 1, giving the motorist approximately a one-third saving in fuel economy.

In the years since Charles made the tests, the octane rating of the gasoline at the corner pump has risen to about 80. Compression ratios have also risen. The 1960 Cadillac, for example, had a ratio of 10.5 to 1. Further improvements in gasoline will result in further gains in fuel economy.

Charles reported the results of his experiments on compression ratio at the summer meeting of the Society of Automotive Engineers at French Lick, Indiana. A year later the American Petroleum Institute gave him its Gold Medal for Distinguished Achievement. At the presentation a prominent oil man said, "Your work has helped us all so much that the oil industry, not the automobile industry, should have been paying your salary."

The report and recommendations at French Lick was the culmination of Kettering's work at GM as vice president and general manager of the research laboratory. Since he had reached seventy the previous August, the time for retirement had arrived.

"What are you going to do now that you're retiring?" a friend asked him one day.

Charles laughed. "I'm like an errand boy I overheard in


the elevator the other day. He said to his friend, 'I get four weeks' vacation this year.' 'How's that?' asked his pal. 'I get my own two weeks and then I'm going to do your work while you're on vacation.' That's what I'm going to do when I retire," he laughed. "Get a job."

It was almost forty-three years to the day since he stuck his head through the door of an office at the National Cash Register Company and said, "Hello. You Mr. Deeds? I'm Charles Kettering."

He started to work for fifty dollars a week; when he retired he was making more than forty times that much.

He had worked hard. He had had good times and bad ones. He had made his mark in the world. And he wasn't finished yet!

15

 One of his first jobs after he retired to Ridgeleigh Terrace was to enlarge the staff working on why the grass is green.

"We need more room," said Charles. "My house is pretty big and empty. Down in my basement is a room for a bowling alley. Who has time to bowl? We'll put about five laboratories in there. And we can put a conference room, a library, and an office in the billiard room, and we'll make a dark room out of the organ chamber."

Before long the cheery sound of saws and hammers began to float out of the basement.

Charles had said in the beginning that the search might be a two- or three-generation job. In the years since the original staff started to work, they had made great progress, but they still had a long way to go.

"Don't you ever get discouraged?" a friend asked Charles. "You have been working on this about thirty-five years and haven't found the answer yet."

"Why get worried about thirty-five years?" he replied. "We have geological data that shows those plants have been growing for about two billion years. So what's thirty-five?"

A magazine writer said something about Kettering's conquest of the secrets of nature.

"Hah!" Charles sniffed when he read it. "It's not the conquest of nature, it's the conquest of our own ignorance. And as for secrets, there is only one secret of nature I want to

pry into. Why is the human skull as dense as it is? Nowadays we can send a message around the world in one-seventh of a second, but it takes years to drive an idea through a quarter-inch of human skull."

Charles had deep respect for nature. "We don't need to hammer our chests and think we have accomplished so much in science and engineering," he said. "The world was all here before we came.

"We think the spectroscope is a pretty good means of identifying extremely small quantities. An old hound dog can show up the spectroscope. He can go down a road where ten people have walked and turn down the right lane to get to the house where his master is—all by smell alone.

"We think we are smart because we have been flying for about sixty years. Birds and bees and butterflies have been flying for hundreds of thousands of years.

"We think we are pretty good navigators. I have taken homing pigeons from Springfield and Dayton and Xenia part of the way to Detroit. There was no way for them to know the way they had come, but when I released them near Detroit, the Xenia birds flew back to Xenia, the Springfield birds to Springfield, and the Dayton birds to Dayton.

"We think we have done pretty well to develop sound reflection to determine the depth of ocean and nearness of ships in a fog. But the bat has been using sound projection for years to fly in the dark. If you blindfold a bat and force him to fly through two wheels revolving in different directions, he will fly through the wheels without hitting a spoke."

In October, 1948, Charles learned that his sister Daisy had cancer. He asked Dr. Cornelius P. Rhoads, director of Sloan Kettering Institute, to go with him to see her and confer with her doctor. After a rather discouraging confer-

ence in Mansfield, Charles drove Rhoads to Loudonville. He showed him the high school he had attended and the mill where he used to stop to watch the Corliss engine. They went past the Flxible Corporation, buzzing with work. Then they drove the three miles of hilly road to the farm.

"When I used to walk these three miles back and forth to school every day," Charles told him, "I had no idea I was underprivileged. I thought it was an opportunity!"

Daisy went for treatment to Memorial Hospital, but she died the following April.

People living in Van Buren township, the area south of Dayton in which Ridgeleigh Terrace is situated, honored Charles in 1952 by incorporating as the village of Kettering. Said the leaders of the plan:

"The selection of the name of Kettering is a tribute of praise to a man of service to his fellow men. While one we revere is yet alive, we thus create a living memorial in his honor."

At the time of incorporation Kettering had a population of 20,000. It became a city in 1955 and now has a population of more than 50,000.

In 1953 a new Charles F. Kettering Foundation building was dedicated in Yellow Springs. In the building the search for the answer to "Why is the grass green?" continued, as well as research on magnetism and cancer.

It is expected that the whole answer will be learned in the near future. Economists predict that the world demand for food will be twice the present production. Our present wasteful methods of agriculture cannot feed increasing billions of people. Dr. Howard A. Tanner, research director of the Foundation, says:

"In our present state of using the sun's power we are like children admiring the fabulous delicacies in a bakeshop window. All we have yet been able to capture is a tantalizing whiff of what is inside the shop."

Two years after the Foundation building was completed, Charles spoke at the dedication of the Olive Kettering Memorial Library at Antioch. He told the guests, "One of the things I would like to see you put above the door of this library is 'Enter here at your own risk!' Your chances of getting misinformation are much greater than getting correct information. Don't read a book unless you know what the fellow did who wrote it, outside of writing a book. There are thousands of books with nothing in them but paper."

Charles also gave to Antioch the Student Union and the remodeled Horace Mann Hall. He also made gifts to Ashland, Wooster, Earlham, and Wilmington Colleges.

After his retirement he had more time to travel making speeches. Every year he flew thousands of miles to appear before professional groups. His speeches, always impromptu and informal, sparkled with wit and pithy good sense. He enjoyed speaking of his own profession.

"Inventors are almost a disappearing group. Most people think of them as longhairs or screwballs, and we are so small in numbers that we dare not say what we think about people.

"What is the difference between most people and inventors? For one thing most people are interested in where they came from. Inventors are interested in where they are going.

"Perhaps the difference between a scientist and the inventor can best be illustrated by a loom, where you have the threads called the warp running lengthwise of the loom. These represent your physicists, chemists, biologists, and so

forth. The threads that are put in at right angles by the shuttle are the woof. These represent the work of the inventor.

"The inventor cannot be just a physicist, a chemist, or a biologist, he has to be whatever is necessary to get the job done. He may have to use some physics, some chemistry, and something else. He has got to tie the threads together.

"Now, if you don't think the woof man is essential, try to sleep in a scientific hammock and see what happens."

"If society is to survive," he told businessmen, "the obsolescence factor must be better understood. No article should be kept off the scrap pile longer than it takes to provide a better article. This is not waste. Waste comes when we cling too long to the old things."

He believed that any house or commercial building that is not air-conditioned is dangerously obsolete. The cost of air conditioning is not expensive, he contended, because it results in increased health and efficiency. "Nothing could be more wasteful," he frequently pointed out, "than to live less effectively than is possible."

Charles snorted whenever he saw a business that pointed with pride to its white-bearded founders of a century ago. "Our greatest industries in this country today are the new ones. They are dominated by men who haven't any whiskers growing on their chins or minds. They are young and simple and ignorant enough to suppose that anything they can imagine they can do. So they imagine things and do them."

People who heard Kettering's speeches often quoted and requoted some of his memorable remarks, such as:

The worst thing a business can have is satisfied customers. Satisfied customers can kill a business deadlier than a doornail.

When people are doing well, they have less incentive

to change. Yet change is essential to continued prosperity.

When we know a little about a subject, we say it is a very difficult problem. If we know nothing about it, it is a very, very difficult problem.

Leisure never created anything. Nobody ever made anything worth while watching the clock.

It is man's destiny to ponder on the riddle of existence and, as a by-product of his wonderment, to create a new life on this earth.

We cannot turn back. There is no direction to go except forward.

Nobody ever found anything while sitting down.

Thinking is the one thing in the world upon which no one has ever been able to put a tax or tariff.

Just the minute you are satisfied with what you've got, the concrete has begun to set in your head.

We should all be concerned about the future because we have to spend the rest of our lives there.

It isn't the things that you don't know that get you into trouble, it's the things you know for sure that are not so.

There will always be a frontier where there is an open mind and a willing hand.

Charles held honorary and life memberships in thirty-three professional and learned societies and was a member of fifty-eight others. Among his forty-nine trusteeships and directorships he was president of the Thomas Alva Edison Foundation, director of the Ethyl Corporation, GM, NCR, Sloan Kettering, and trustee of Ohio State University and Antioch College. He attended the monthly meetings of Ethyl Corporation and GM in New York and dropped in at Sloan Kettering on his monthly trips to the city.

He received fifty-five decorations and awards and thirty-eight honorary doctor's degrees.

With the exception of his early eye trouble, Charles had excellent health and unusual energy. During his eightieth year he traveled 75,000 miles filling speaking engagements.

At the funeral of his last brother, Adam, who died March 28, 1958, someone asked him whether he worried about getting older. "Why no," he replied. "If you're getting older, you're still alive."

Early in May his old friend since early NCR days, Bill Chryst, died. His death, following so soon that of his last brother, affected Charles deeply.

Gene and Virginia customarily flew to Dayton from Hinsdale to spend week ends with him. Usually they found him spending long hours on his magnetism project. When Virginia worried about his driving himself so hard, he told her, "Time is getting short for me."

Early in November of 1958 Charles had a call from Gene reminding him of their annual Thanksgiving dinner in New York with the grandchildren and great-grandchildren.

"Oh, I'm so busy," he said. "I'll just fly down for dinner and right back. I've got so much to do."

He did have much to do. He flew on November 12 to Cleveland to address the International Medical Assembly. The following day he gave the keynote address at the Thomas Alva Edison Foundation Institute. Four days later he spoke in Dayton at the National Inventors Council. Four days after that he flew to Detroit to attend a farewell dinner for retiring GM stylist Harley J. Earl. At the reception he felt a little under the weather.

Friends in Detroit called his Dayton staff. When Charles arrived at the airport on Friday, a doctor met him. He was

furious. "I'm not sick. I don't need a doctor," he said. "It's just a little touch of ptomaine."

Although he was advised to go to bed, he refused. Gene and Virginia flew in from Hinsdale for their usual week-end visit, arriving on Saturday afternoon.

They had a good visit. On Sunday they had dinner together at the Moraine Country Club. Before Virginia and Gene left for Hinsdale, they privately asked Robert McClarin, the house man, to sleep in the little sewing room next to Charles' room and look in on him from time to time.

After the children left, Charles returned to the club where he had dinner with friends. Then he went back home and to bed.

Robert checked him several times during the night. He seemed to be sleeping soundly.

But next morning he failed to come downstairs for breakfast at the usual time. An early morning caller, Dr. Douglas Talbott, with whom Charles often talked on medical matters, dropped in for a chat.

"Mr. Kettering isn't down for breakfast," Robert told him. "I think we'd better wake him."

The doctor hurried upstairs, followed by Robert and Elmira, his wife. As soon as Talbott saw Charles from the door, he exclaimed, "He's had a stroke!"

He examined Charles and sent for an oxygen tent. Robert telephoned Gene and Virginia, who flew back from Hinsdale, arriving about ten o'clock. They sent for the rest of the family.

He never regained consciousness. He had a second stroke on Monday and a third on Tuesday. He died on Tuesday afternoon, November 25, 1958, in his own bed at home.

His body lay in state on Thanksgiving Day in the En-

gineers' Club, which he and Edward Deeds had built so long ago.

Services were held the following day at Christ Episcopal Church on the snowiest day of the year. The weather was so bad that nine planes flying friends to the funeral from Detroit were grounded. Four planes—two from New York, one from Flint, and one from Wilmington, Delaware—attempted the flight and made it. Among the many friends who followed Charles to his long home beside Olive in snowy, wind-swept Woodland Cemetery were Alfred P. Sloan, Jr.; John L. Pratt, friend of cruise days; Dr. C. P. Rhoads, of Sloan Kettering; O. Lee Harrison, the Philadelphia battery salesman; and, oldest friend of all, his neighbor Edward A. Deeds.

Although Charles Kettering died before he found the answer to why the grass is green, how to cure cancer, and how the magic fingers of a magnet work, he left his estate to the Foundation so that some day the questions will have an answer. And on the grounds of Ridgeleigh Terrace will be the Kettering Memorial Medical Center, including a hospital, a medical research building, and a museum.

The honors he received and the fortune he made from the 200 patents he held never changed him from the modest, fun-loving boy who came out of the Ohio hills to change his world.

In the last year of his life he went to Washington to receive the Greatest Living American Award from the United States Chamber of Commerce. After the ceremonies a reporter asked, "Mr. Kettering, how does it feel to be one of the greatest living Americans?"

Charles' face flushed as he looked down at his hands so used to screwdriver and pliers. "They didn't need to make so much fuss," he said. "I'm just a plain, old inventor!"

"Let us not become great egotists just because we have made some progress," he once said. "There are many problems yet to be solved, and it seems to me there are just about as many things to be done now as when I was a boy, but the opportunities are so much greater. So let's get to work."

Charles Franklin Kettering

DECORATIONS and AWARDS

1922	Hall of Fame	Aeronautical Association of America
1928	Honorary Fellow	National Academy of Sciences
1929	Sullivant Medal	The Ohio State University
1930	Benefactor of Dayton Medallion	Civitan Club, Dayton, Ohio
1930	Award	American Philosophical Society
1936	Washington Award	Western Society of Engineers and Four Founders Societies
1936	John Scott Memorial Award	Board of City Trusts, Philadelphia
1936	Franklin Medal	The Franklin Institute of Philadelphia
1937	Medal	American Club of Paris, France
1937	Chevalier, Legion of Honor	Republic of France
1938	Honorary Fellow	International College of Dentists
1938	Order of La Couronne (France)	
1938	Officer of the Order of The Crown	Leopold III, Belgium
1940	Gold Key	American Congress of Physical Therapy
1940	Modern Pioneers Award	American Manufacturers Association
1941	Honorary Fellow	Leland Stanford University
1943	Certificate for William Park Woodside Lecture	American Society for Metals (Detroit)
1943	Honorary Fellow	University of Nebraska
1944	John Fritz Medal	Representative Societies Board of Awards, American Society of Civil Engineers, American Society of Me- chanical Engineers, American In- stitute of Electrical Engineers, American Institute of Mining, Metallurgical and Petroleum En- gineers
1945	Thomas A. Edison Award	Society of Arts and Sciences
1946	Certificate for Andrew R. Biddle Oration	Michigan State Medical Society

1946	Tribute	Citizens of Loudonville, Ohio
1947	Silver Beaver Award	Boy Scouts of America
1947	Distinguished Health Service Award	Michigan State Medical Society
1948	Alumnus of The Year	American Alumni Council, Detroit Chapter, O S U Alumni
1948	Certificate, Schwab Memorial Lecture	American Iron and Steel Institute
1948	Citation for Outstanding Accomplishment as Salesman and Scientist	National Federation of Sales Executives and The Sales Executives Club of New York
1948	Distinguished Service Citation	Automobile Old-Timers
1948	Gold Medal for Distinguished Achievement	American Petroleum Institute
1948	Award for Distinctive Services	American Hospital Association
1949	Citizenship Award	Ohio State Bar Association
1949	Gold Medal	International Benjamin Franklin Society
1950	Certificate of Appreciation	Ohio Society of Professional Engineers
1950	Governor's Award	Ohio Newspaper Association
1950	Silver Buffalo Award	Boy Scouts of America
1950	Award of Achievement	Advertising Club of New York
1950	Ohioana Library Science Award	Ohioana Library Association
1951	Centennial Award	Northwestern University
1952	Horatio Alger Award	American Schools and Colleges
	Jefferson Medal	New Jersey Patent Law Association
1953	Gold Medal	National Institute of Social Sciences
1953	Award for 1953	National Society of Professional Engineers
1954	Engineer of the Year	National Association of Power Engineers
1954	Knight of The Round Table	National Management Association
1954	Citation	Newcomen Society of North America
1955	Hoover Medal	American Society of Mechanical Engineers
1955	Silver Quill Award	National Business Publications, Inc.
1956	Certificate	American Medical Association
1956	Achievement Award	Ohio Society of New York

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| 1956 | Charles Franklin Kettering Award (First Award) | American Society of Civil Engineers,
American Society of Mechanical Engineers, American Institute of Electrical Engineers, Society of Automotive Engineers, American Institute of Chemical Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers |
| 1956 | Industrialist of the Year | Society of Industrial Realtors |
| 1956 | Testimonial Plaque | Illinois Manufacturers Association |
| 1957 | Harry E. Salzberg Medal | Syracuse University |
| 1957 | Award for Outstanding Contribution to Agriculture | Ohio Farm Bureau Federation |
| 1958 | Greatest Living American Award | United States Chamber of Commerce |
| 1958 | Citation | Interstate Post-Graduate Medical Association of North America |
| 1959 | Edison Gold Medal | American Institute of Electrical Engineers |

DEGREES

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|------|------------------------------------|---------------------------|
| 1904 | Graduate in Electrical Engineering | The Ohio State University |
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Honorary Degrees

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| 1929 | Dr. Engineering | The Ohio State University |
| 1929 | Dr. Engineering | University of Michigan |
| 1931 | Dr. Science | University of Cincinnati |
| 1932 | Dr. Engineering | Polytechnic Institute of Brooklyn |
| 1932 | Dr. Science | Brown University |
| 1934 | Dr. Engineering | University of Detroit |
| 1934 | Dr. Science | Toledo University |
| 1935 | Dr. Science | Northwestern University |
| 1936 | Dr. Science | Lafayette College |
| 1937 | Dr. Science | New York University |
| 1939 | Dr. Science | Dartmouth College |
| 1939 | Dr. Science | Harvard University |
| 1942 | Dr. Science | Otterbein College |
| 1943 | Dr. Engineering Research | University of Nebraska |

1943	Dr. Science	Columbia University
1943	Dr. Laws	Antioch College
1945	Dr. Science	Syracuse University
1945	Dr. Science	Oberlin College
1946	Dr. Humanities	Temple University
1947	Dr. Science	University of Miami
1947	Dr. Humane Letters	College of Wooster
1947	Dr. Science	Washington University
1947	Dr. Laws	Princeton University
1949	Dr. Laws	Lehigh University
1949	Dr. Science	University of Alabama
1950	Dr. Science	New York State Board of Regents
1952	Dr. Humanities	University of Dayton
1953	Dr. Civil Engineering	Rennselaer Polytechnic Institute
1953	Dr. Science	University of Florida
1954	Dr. Engineering	Worcester Polytechnic Institute
1954	Dr. Science	Butler University
1955	Dr. Science	Wilmington College
1956	Dr. Engineering	Indiana Technical College
1956	Dr. Laws	Wabash College
1957	Dr. Laws	Kenyon College
1958	Dr. Science	Bradley University

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- "Research as Related to Banking," 1936.
- "Looking Forward Through the Eyes of Research," Purdue University, March 4, 1953.
- "How Can We Develop Inventors?" American Society of Mechanical Engineers, November 29, 1943.
- "Centennial Address," Mount Union College, Alliance, Ohio, June 2, 1946.
- "More Efficient Utilization of Fuels," Society of Automotive Engineers, French Lick, Indiana, June 1, 1947.
- "Remarks Before a Meeting of Corporate Executives and Bankers," Pittsburgh, Pennsylvania, April 16, 1947.
- "Remarks on Receiving the Award of Merit of the American Alumni Council," Ann Arbor, Michigan, July 13, 1948.
- "Remarks at the Dedication of the Lobund Institute," Notre Dame, Indiana, December, 1950.
- "The Source of Life," Fairfield Tropical Garden, Florida, February 18, 1952.
- "Address Before the Annual Banquet," American Society of Mechanical Engineers, New York, December 3, 1952.
- "The Machine Tool Industry's Part in the Development and Future of America," American Machine Tool Distributor's Association, Cincinnati, Ohio, April 16, 1953.
- "Address Before the Tenth Annual Advisory Council of the Southern Research Institute," Birmingham, Alabama, October 4, 1954.
- "Address Before the Schenectady General Electric Engineers Association," Schenectady, New York, April 22, 1955.
- "Keynote Address, 33rd Annual Meeting of Federation of Paint and Varnish Production Clubs," New York, October 3, 1955.
- "Address Before the Annual Meeting of the American Institute of Consulting Engineers," New York, October 25, 1955.
- "Address Before the Eleventh Annual Advisory Council of the Southern Research Institute," Birmingham, Alabama, November 10, 1955.
- "An Inventor Looks at Education," Sixth Annual Thomas Alva Edison Foundation Institute, New York, November 21, 1955.

- "Talk Before the Convention of Maryland High School Principals and Supervisors," Baltimore, Maryland, April 12, 1956.
- "Talk," Atomic Forum, Atlanta, Georgia, April 17, 1956.
- "On the Occasion of the 50th Anniversary of Cooperative Education," University of Cincinnati, Cincinnati, Ohio, April 20, 1956.
- "Commencement Address," Indiana Technical College, Ft. Wayne, Indiana, May 20, 1956.
- "Ninth Annual Salzberg Memorial Lecture," Syracuse University, Syracuse, New York, April 2, 1957.
- "An Inventor Looks at Technical Education," Egleston Award Dinner, Columbia Engineering Alumni Dinner, New York, April 14, 1957.
- "Economics and Technology," Conference on the Economic Future of the South, Birmingham, Alabama, May 20, 1958.
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